LOWER CAMBRIAN ARCHAEOCYATHA FROM THE AJAX MINE, BELTANA, SOUTH AUSTRALIA

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LOWER CAMBRIAN ARCHAEOCYATHA FROM THE AJAX MINE, BELTANA, SOUTH AUSTRALIA

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CONTENTS

SYNOPSIS

Specimens from the Ajax Mine, first described by R. & W. R. Bedford (1934, 1936) and now in the British Museum (Natural History), have been re-examined and are revised. Fifteen families, 21 genera, 4 subgenera and 41 species are discussed and arranged according to current classification. One family (Ethmocyathidae), one genus (*Cyathocricus*), three subgenera (*Loculicyathellus*, *Erugatocyathus*, *Anaptyctocyathus*) and one species (*Anaptyctocyathus flabellus*) are considered new. The two genera *Metacyathus* and *Bedfordcyathus* are shown to be synonyms of *Metaldetes*. The excellent preservation of this silicified material has enabled the internal structures of some species to be determined accurately and resulted in the discovery of new wall and intervallum types.

Stratigraphical correlation shows that there are clear affinities between the Ajax, Kameshki and Sanashtygkol faunas. The presence of both advanced and simple forms in the Ajax fauna indicates that it is probably of Upper Kameshki–Lower Sanashtygkol age, i.e. the middle of the lower division of the Lower Cambrian.

Ce travail a pour but de reviser les Archéocyathes qui firent l'objet du premier mémoire de R. et W. R. Bedford (1934) et qui sont actuellement conservés dans les collections du B.M.(N.H.). 15 familles, 21 genres, 4 sous-genres et 41 espèces sont décrits et classés selon les critères actuels de classification. Une nouvelle famille (Ethmocyathidae), un nouveau genre (*Cyathocricus*), trois sous-genres (*Loculicyathellus*, *Erugatocyathus*, *Anaptyctocyathus*) et une nouvelle espèce ont été établies. *Bedfordcyathus* et *Metacyathus* tombent en synomymie avec *Metaldetes*. La fossilisation exceptionnelle du matériel silicifié a permis la définition de nouvelles structures murales et intervallaires.

Les faunes d'Ajax ont des affinités avec les faunes des horizons de Kameshki et Sanashtygkol, c'est à dire qu'elles datent du milieu de la partie inférieure du Cambrien inférieur.

I. INTRODUCTION

THE present work is a revision of material in the British Museum (Natural History) collection, collected and originally described by R. & W. R. Bedford in 1934. The specimens come from a Lower Cambrian exposure in a limestone hill behind the Ajax copper mine, ten miles north-east of Beltana, in the Flinders Range, South Australia. T. G. Taylor was the first to visit this locality in February, 1906 and his subsequent monograph on Australian Archaeocyatha (1910) was the first work to give detailed descriptions of such fossils.

In a series of papers from 1934–1939, the Bedfords, R., W.R. & J., described material collected in South Australia. The specimens mentioned in their papers now belong to the following museums, according to correspondence in the British Museum (Natural History) from Dr. Dorothy Hill: Memoir 1—B.M. (N.H.); Memoir 2—South Australian Museum; Memoirs 3, 4 and 6—Princeton University, U.S.A. The remain-

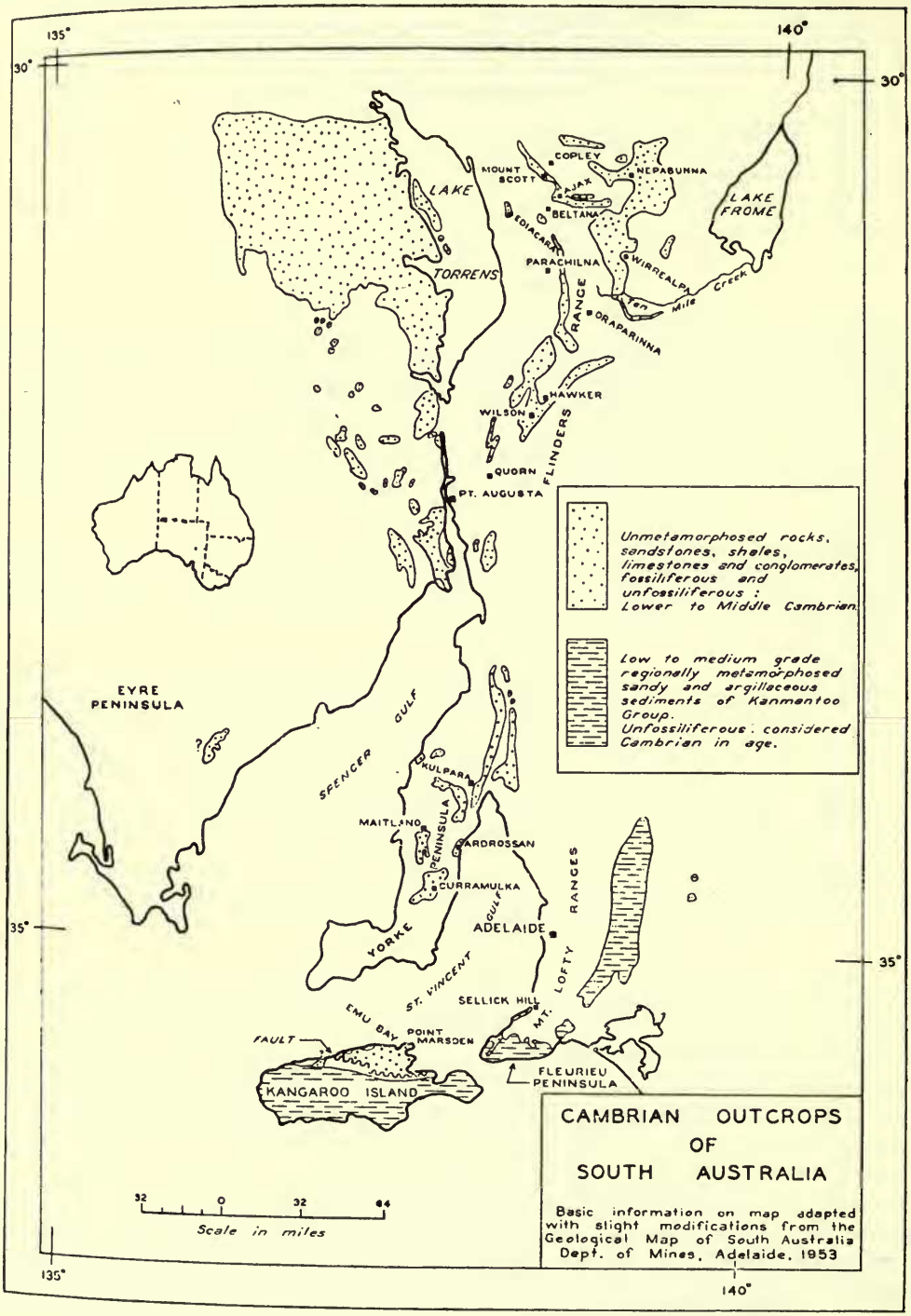

FIG. 1. The Cambrian outcrops of South Australia. After B. Daily, 1956.

der of the Bedford collection was acquired by Prof. D. A. Brown of the Geology Dept, Australian National Museum, Canberra.

The silicified Australian material enabled both Taylor and the Bedfords to discover details of the finer internal structure by etching their specimens. Some credit is due to the Bedfords for the classification of the Archaeocyatha and their recognition of the systematic importance of ontogeny in such a classification.

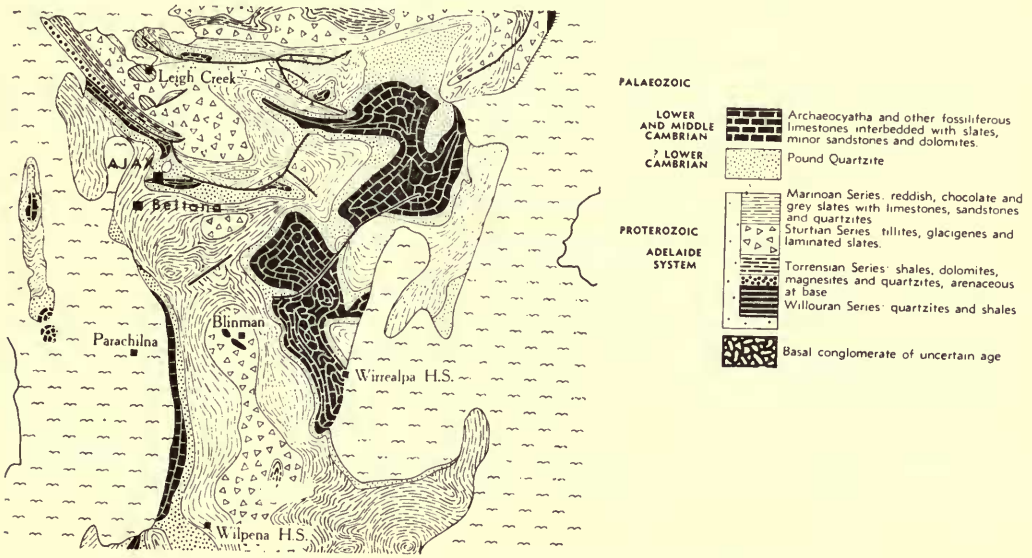

FIG. 2. Section from a generalized geological map of the Flinders Ranges, produced by the Geol. Survey of South Australia and published in Glaessner, M. F. & Parkin, L. W. 1958.

The study of Archaeocyatha has figured prominently in assigning a Cambrian age to these rocks. Daily (1956) recognized 5 faunal assemblages in the Ajax limestones, but considered that the material collected by both Taylor and the Bedfords could only come from his faunal assemblage No. 1, which is given a Lower Cambrian age. Yet Walter (1967) states that the Ajax fauna cannot be placed in Daily's scheme of faunal units.

Recently Dorothy Hill (1965), in her work on Antarctic Archaeocyatha, revised the phylum and provided good illustrations of type material in Adelaide University, the South Australian Museum, Princeton University and the British Museum (Nat. Hist.). At her suggestion, I undertook the study of the Bedford material in the latter collection, with the intention of providing further description, re-classification and, above all, better figures of the specimens. It has often been difficult in the past to assess the characters of genera and species mentioned by the Bedfords, as their figures are either composite, or cannot be located on the actual specimen. The genus *Syringocnema* is not dealt with in this paper, although well represented in that part of the Bedford collection in the B.M. (N.H.), because of its thorough description by both Taylor (1910 : 153) and Gordon (1920 : 699).

" Archaeocyatha are known from all the continents except South America and are characteristic of the calcareous facies of the Lower Cambrian " (Hill 1965 : 30). This widespread distribution makes them particularly useful for stratigraphical correlation; yet, as Walter (1967) points out, their use is limited for, being benthonic, dispersal is restricted. " Recognition of the extinct Archaeocyatha as a separate phylum near the Porifera and Coelenterata, is now general " (Hill 1965 : 45). In the past, their systematic position has been the subject of considerable debate, with opinion ranging from calcareous algae to sponges. However, they are regarded by Hill (1964 : 253) " as single multicellular organisms, with organization higher than that of the Protozoa, but with less differentiation than the Porifera ".

A short glossary of the more important descriptive, morphological terms is included as an Appendix.

II. SYSTEMATIC DESCRIPTIONS

Phylum ARCHAEOCYATHA Vologdin, 1937

Class *REGULARIA* Vologdin, 1937

Order MONOCYATHIDA Okulitch, 1935

Family ***MONOCYATHIDAE*** R. & W. R. Bedford, 1934

DIAGNOSIS. Single-walled cup. Pore system simple to slightly complex.

COMPOSITION OF THE FAMILY. *Monocyathus* Bedford, R. & W.R. 1934, *Rhabdolynthus* Zhuravleva 1960, *Tumuliolynthus* Zhuravleva 1963, ? *Tunkia* Bedford, R. & J. 1936.

Genus ***MONOCYATHUS*** R. & W. R. Bedford, 1934

1899 *Rhabdocyathus* von Toll (*non* Brooks 1893): 45, pl. 8, figs. 2c, 6 and 7, t.-figs. 4–7.
1910 *Archaeolynthus* Taylor : 157, pl. 5.
1934 *Monocyathus* R. & W. R. Bedford : 2, pl. 1, fig. 1.
1936 *Monocyathus* R. & W. R. Bedford : 12, pl. 10, fig. 46.
1937 *Rhabdocnema* Okulitch : 251
1939 *Monocyathus* R. & W. R. Bedford; R. & J Bedford : 69, pl. 42, fig. 161.
1939 *Archaeolynthus* Taylor; Simon : 21.
1949 *Archaeolynthus* Taylor; Zhuravleva : 549.

TYPE SPECIES. *Monocyathus porosus* R. & W. R. Bedford, 1934, selected by R. & W. R. Bedford, 1936.

DISCUSSION. Okulitch (1950), Debrenne (1964) and Hill (1965) consider *Archaeolynthus* Taylor 1910 an invalid name, as the type specimen was not designated by the author and the reference material was destroyed by serial sectioning.

DIAGNOSIS. Small conical cups with a simple porous single wall and the vertical rows of pores in a quincunx pattern.

COMPOSITION OF THE GENUS. *Monocyathus absolutus* (Vologdin 1940), *M. bilateralis* (Vologdin 1962), *M. contractus* Hill 1965, *M. copulatus* (Vologdin 1940), *M. kuzneskii* (Vologdin 1931), *M. lebedevae* (Vologdin 1937), *M. macrospinosus* (Zhuravleva 1963), *M. mellifer* R. & W. R. Bedford, 1936, *M. nalivkini* (Vologdin 1939), *M. operculatus*

Maslov 1960, *M. partibus* (Vologdin 1963), *M. polaris* (Vologdin 1937), *M. porosus* R. & W. R. Bedford, 1934, *M. robustus* R. & W. R. Bedford, 1936, *M. sibiricus* (von Toll 1899), *M. simplex* (Vologdin 1940), *M. sparsipora* R. & W. R. Bedford, 1936, *M. spinosus* R. & W. R. Bedford, 1936, *M. tenuimurus* (Vologdin 1940), *M. tolli* (Krasnopeeva 1937), *M. unimurus* (Vologdin 1940).

Monocyathus porosus R. & W. R. Bedford

(Pl. 1, fig. 3)

1934 *Monocyathus porosus* R. & W. R. Bedford : 2, pl. 1, fig. 1.
1939 *Monocyathus porosus* R. & J. Bedford : 69, fig. 161.
1963 *Archaeolynthus porosus* (Bedford & Bedford); Zhuravleva : 88–89, fig. 39.
1965 *Monocyathus porosus* R. & W. R. Bedford; Hill : 52, pl. 2, fig. 1.

Lectotype. B.M. (N.H.) S 4140 selected by Hill (1965).

Other Material. Syntypes B.M. (N.H.) S 7630–31, S 4783–8.

Description. Conical cup, slightly waved, with a single wall of constant thickness and pores in quincunx. The upper edge, in the material studied, is not turned back into the central cavity as an incipient pelta. The pores are proportionately smaller and more numerous towards the upper part of the cup. The bigger specimens have smaller and more regular pores.

Dimensions

	Lectotype (mm.)	S 7630–7631 (mm.)
Height (*pars*)	15	31
Diameter	6	9·5
Wall:		
Diameter of the pores	0·27–0·20	0·10
Distance between the vertical rows	0·33–0·27	0·33
Distance between the horizontal rows	0·54–0·67	0·35

Discussion. This species is very similar to the Siberian species *M. nalivkini* (Vologdin). Zhuravleva (1963 : 80) distinguishes the two, mainly on the supposed presence of a pelta and inner rugosity in *porosus*, which was described and figured by R & W. R. Bedford (1936). However, these peculiar structures are neither seen in the lectotype, nor on the other specimens in the British Museum collection. It is therefore possible that the two species are synonymous.

Monocyathus mellifer R. & W. R. Bedford

(Pl. 1, fig. 4)

1936 *Monocyathus mellifer* R. & W. R. Bedford : 12, pl. 10, fig. 49.

Material. B.M. (N.H.) S 4821. The whereabouts of the holotype is not known.

Remarks. The specimen is a cylindrical fragment of a single-walled cup. The wall is like a honeycomb, formed by short hexagonal pipes with a hexagonal section on the outer side and a circular section on the inside.

DIMENSIONS

	(mm.)
Height (pars)	16
Diameter	3·72
Wall:	
Inner diameter of pores	0·40
Pipe wall thickness	0·27
Wall thickness	0·67

DISCUSSION. This fragmentary piece is similar to the type-species briefly described by R. & W. R. Bedford 1936.

Genus *TUMULIOLYNTHUS* Zhuravleva, 1963

1932 *Rhabdocyathus* von Toll : Vologdin (pars) : 65.
1963 *Tumuliolynthus* Zhuravleva : 101.

TYPE SPECIES. *Rhabdocyathus tubexternus* Vologdin 1932, by original designation Zhuravleva (1963 : 101).

DIAGNOSIS. One-walled Archaeocyatha, with the pores protected externally by simple tumuli.

COMPOSITION OF THE GENUS. (After Zhuravleva 1963): *T. irregularis* (R. & W. R. Bedford, 1934), *T. karakolensis* Zhuravleva 1963, *T. musatovi* (Zhuravleva 1961), *T. tubexternus* (Vologdin 1932), *T. vologdini* (Yakovlev 1956).

Tumuliolynthus irregularis (R. & W. R. Bedford)

(Pl. 1, fig. 1)

1934 *Monocyathus irregularis* R. & W. R. Bedford : 2, pl. 1, fig. 2.
1939 *Monocyathus irregularis* R. & W. R. Bedford; R. & J. Bedford : 68, fig. 160.
1963 *Tumuliolynthus irregularis* (R. & W. R. Bedford) Zhuravleva : 110, fig. 58.

HOLOTYPE. B.M. (N.H.) S 4141.

OTHER MATERIAL. B.M. (N.H.) S 7643–6, S 4771, S 4774–7, S 4764–5.

REMARKS. The holotype is a small cylindrical fragment with several large apertures, each of which is probably the basal trace of a pore. The scattered tumuli occur on the lower parts and have a large opening at the top. The poor preservation and small size of this specimen prevent a more detailed description. The other specimens are more complete, generally larger, and have a thicker wall with irregular apertures, each with a tumulus perforated at the top.

DIMENSIONS

	S 4141 (mm.)	S 4774–4777 (mm.)	S 4817–4820 (mm.)
Cup:			
Height	6·1	..	18
Diameter	1·69	0·33	0·27
Wall:			
Diameter of pores	0·60–0·23	0·20	0·27
Average distance between pores	..	0·67	..
Thickness	0·10	0·33	0·27

Discussion. R. & W. R. Bedford, (1934) and R. & J. Bedford, (1939) noted the presence of " papillae " and only placed this species in the genus *Monocyathus* provisionally. Zhuravleva (1963) uses the term " tumulus " when referring to the papillae and after examining the material, I consider her change of terminology justified.

Tumuliolynthus irregularis differs from other species of the genus by the irregular size and pattern of its pores.

Order AJACICYATHIDA R. & J. Bedford, 1939

Family ***DOKIDOCYATHIDAE*** R. & W. R. Bedford, 1936

Diagnosis. Two-walled cup, walls simply porous, connected by radial horizontal rods.

Composition of the Family, *Dokidocyathus* Taylor 1910, *Alphacyathus* R. & J. Bedford, 1939.

Genus ***ALPHACYATHUS*** R. & J. Bedford

1939 *Alphacyathus* R. & J. Bedford : 72.

Type Species. *Dictyocyathus annularis* R. & W. R. Bedford, 1936, by original designation R. & J. Bedford, (1939 : 72, fig. 55).

Diagnosis. Cup with two simply porous walls. In the intervallum, radial cylindrical bars are arranged in regularly spaced horizontal planes and are connected by synapticulae that are opposite from loculus to loculus, forming a continuous ring in the centre of the intervallum.

Composition of the Genus. A single species *Alphacyathus annularis* (R. & W. R. Bedford, 1936).

Alphacyathus cf. ***annularis*** (R. & W. R. Bedford)

(Pl. 1, fig. 2)

cf. 1936 *Dictyocyathus annularis* R. & W. R. Bedford : 13, pl. 11, fig. 55.
1939 *Alphacyathus annularis* R. & W. R. Bedford) R. & J. Bedford : 72.

Holotype. P 942 in the South Australian Museum, Adelaide according to Hill (1965 : 55).

Other Material. B.M. (N.H.) S 4822, S 4766.

Description. Small cylindrical cups. Outer wall is pierced by circular pores in quincunx, the skeletal tissue between the pores (" linteaux ") is of constant thickness and equal in width to the pore diameter. Inner wall is built on the same pattern with regular pores and considerable skeletal tissue. One inner wall pore at each interradial space and at each horizontal level.

DIMENSIONS

	S 4822 (mm.)	S 4766 (mm.)
Cup:		
Height	5	unknown
Diameter	2	2·45
Intervallum	0·70	0·50
Central cavity	0·56	0·90
Outer wall:		
No. of pores between 2 bars	2–3	2–3
Diameter	0·07	0·07
Vertical partitions	0·07	0·07
Horizontal partitions	0·07	0·07
Thickness	0·07	0·07
Inner wall:		
No. of pores between 2 bars	1	1
Diameter	0·15	0·13
Vertical partitions	0·07	0·15
Horizontal partitions	0·07	0·15
Thickness	0·07	0·15
Rods:		
Interradial space	..	0·2
Vertical space	0·2	..
Diameter	0·15	0·15

DISCUSSION. Neither specimen provides a sufficiently complete transverse section for showing the synapticulae and they cannot be assigned with certainty to *annularis*.

Family *ACANTHINOCYATHIDAE* R. & W. R. Bedford, 1936

DIAGNOSIS. Two-walled cups with intervallar horizontal rods. Inner wall simple, but outer wall has protected pores, the lower skeletal part of each pore bearing a long spinous process, projecting upwards and outwards from the wall.

COMPOSITION OF THE FAMILY. *Acanthinocyathus* R. & W. R. Bedford, 1934.

Genus *ACANTHINOCYATHUS* R. & W. R. Bedford, 1936

1934 *Acanthocyathus* R. & W. R. Bedford (non Edwards & Haime 1848, which is a hexacoral) : 4.
1936 *Acanthinocyathus* R. & W. R. Bedford : 11.

TYPE SPECIES. *Acanthocyathus apertus* R. & W. R. Bedford (1934 : 4, fig. 20), by monotypy.

DIAGNOSIS. Two-walled cups with radial, horizontal, or upwardly oblique rods. The outer wall pores are partly obscured by scales. The inner wall consists of a net of polygonal to circular pores.

COMPOSITION OF THE GENUS. *A. apertus* (R. & W. R. Bedford), ? *A. transiens* R. & J. Bedford 1939.

Acanthinocyathus apertus R. & W. R. Bedford

(Pl. 2, Text-fig. 3)

1934 *Acanthocyathus apertus* R. & W. R. Bedford : 4, fig. 20.
1936 *Acanthinocyathus apertus* (R. & W. R. Bedford); R. & W. R. Bedford : 11, fig. 45.

LECTOTYPE. B.M. (N.H.) S 4166 chosen here.

OTHER MATERIAL. Para-lectotypes B.M. (N.H.) S 4167–8.

DESCRIPTION. Cylindrical rods cross the intervallum and are orientated horizontally, or sometimes obliquely upwards and outwards from the inner to the outer wall.

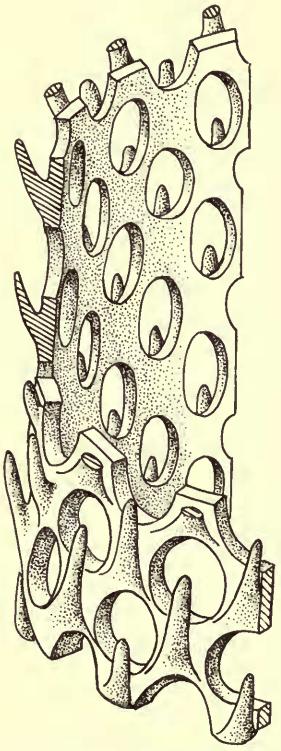

FIG. 3. *Acanthinocyathus apertus* R. & J. Bedford

The inner wall is well shown in S 4168; it consists of a large pored net, with a mesh of irregular size and shape formed by skeletal threads of constant thickness. The outer wall is the most characteristic feature of this species; the large pores are in quincunx and of various shapes; the skeletal tissue occupies a smaller area than the pores and carries long spines that are directed upwards and outwards. Unfortunately, these long protective spines are often broken, but when complete they may reach the centre of the overlying pore, that is to say, since the rows alternate, the centre of the pore two rows above. The base of the spine is level with the lower third of the pore.

DIMENSIONS

	Holotype S 4166 (mm.)	S 4168 (mm.)	S 4167 (mm.)
Cup:			
Height (pars)	34	32	25
Upper diameter	17·5	13	11
Lower diameter	15	12·5	8·5
Upper intervallum	3·5	3·4	3
Lower intervallum	3·4	3·4	2·37
Outer wall:			
Diameter of pores	1·7–2	..	1·01–1·35
scales	4·75–6	..	3–4
Vertical partitions	1·35	..	0·67
Horizontal partitions	1·35	..	1·35
Thickness	0·67	..	0·6
Inner wall:			
Diameter of pores	0·75	0·27–2·03	0·6–1·15
Partitions	+	0·61	0·4
Thickness	0·40	0·47	0·4
Rods	0·4	..	..

DISCUSSION. R. & W. R. Bedford, thought the inner wall was a scaffolding of triradiate spicules, the side rays surrounding the pores and the median ray being prolonged into a spinous process directed upwards and outwards. They considered that the spicular elements of *Acanthinocyathus* could indicate a phylogenetic link between Sponges and Archaeocyatha. This suggestion is not borne out by observation. The wall of *Acanthinocyathus* is a porous sheet with the elongation of its horizontal skeletal parts into scales of an unusual size.

Family ***AJACICYATHIDAE*** R. & J. Bedford, 1939

Genus ***ARCHAEOYCATHELLUS*** Ford, 1873

Subgenus ***STAPICYATHUS*** Debrenne, 1964

1873 *Archaeocyathellus* Ford (Pars).
1964 *Archaeocyathellus* (*Stapicyathus*) Debrenne : 127.

TYPE SPECIES. *Archaeocyathus stapipora* Taylor (1910 : 118), by original designation of Debrenne (1964 : 127).

DIAGNOSIS. Conical cups; outer and inner walls with simple pores as in true Ajacicyathidae. Intervallum crossed by imperforate radial septa. The neighbouring loculi only open into one another and into the central cavity, by the stirrup-pores of the inner wall.

REMARKS. Debrenne (1964 : 127) considered this form a non-corrugated subgenus of *Archaeocyathellus* Ford.

COMPOSITION OF THE SUBGENUS. *A.* (*S.*) *stapipora* (Taylor 1910) and ? *A.* (*S.*) *yukonensis* (Okulitch 1957).

Archaeocyathellus (*Stapicyathus*) *stapipora* (Taylor)

(Pl. 1, fig. 5)

1910 *Archaeocyathus stapipora* Taylor : 118, pl. 7, figs. 37 and 38, pl. 3, fig. 10, t-fig. 14.
1939 *Archaeocyathus stapipora* Taylor; R. & J. Bedford : 75.
1939 *Archaeocyathus* (*Protocyathus*) *stapipora* (Taylor) Simon : 54.
1964 *Archaeocyathellus* (*Stapicyathus*) *stapipora* (Taylor) Debrenne : 127.
1965 *Robustocyathus stapipora* (Taylor) Hill : 61 and 68.

LECTOTYPE. Taylor 1910, Pl. 7, fig. 38 G, chosen here. The specimen should be in the University of Adelaide.

OTHER MATERIAL. B.M. (N.H.) S 4733, S 4351–2, S 4138, S 4528, S 4817–20, S 7621.

DESCRIPTION. Narrow intervallum of constant width from the basal conical apex to the upper bowl-shaped cup. Some specimens are more cylindrical. Outer wall thin, pierced by round pores that are arranged quincunxially. Inner wall thicker, with one vertical row of pores in front of each septa; each pore is excavated into its septum so that stirrup-pores are formed. These inner wall pores are also arranged into horizontal lines.

DIMENSIONS

	S 4733 (mm.)	S 4351 (mm.)	S 4352 (mm.)	S 4817–4820 (mm.)	S 7621 (mm.)
Cup:					
Height (pars)	30	40	22	15	20
Diameter	about 40	about 20	about 12	about 35	about 10
Intervallum coeff.	0·02	0·45–0·66	0·1	0·042	0·1
Interseptum	0·339	0·61	0·61	0·74	0·37
Loculi	1/3·4	from 1/1·8 to 1/2	1/2	1/2	1/3·3
Outer wall:					
No of pore rows per interseptum	3	3	3	3 to 4	3
Diameter of pores	0·07	0·07	0·06	0·075	0·07
Vert. partitions	0·068	0·068	0·07	0·068	0·1
Thickness	0·150	0·23	0·15	0·1	0·1
Inner wall:					
No. of pore rows per interseptum	two 1/2	two 1/2	two 1/2	two 1/2	two 1/2
Diameter of pores	0·27	0·27	0·20	0·27	0·27
Vertical part.	0·27	0·33	0·33	0·40	0·27
Horizontal part	0·16	0·27	0·20	0·27	0·20
Thickness	0·1	0·1	0·1	0·1	0·1
Septa	non porous	non porous	non porous	non porous	non porous
Thickness	0·06	0·06	0·07	0·07	0·07

DISCUSSION. Only one species known. The different shapes i.e. cylindrical, or bowl-shaped could conceivably represent different species, but their coefficients are not sufficiently different.

Genus *LOCULICYATHUS* Vologdin, 1931

Subgenus *LOCULICYATHELLUS* nov.

TYPE SPECIES. *Archaeocyathus floreus* R. & W. R. Bedford 1934.

DIAGNOSIS. Cup has the generic characters of *Loculicyathus*: thin porous walls and septa, vesicular tissue crossing intervallum and central cavity. The external longitudinal corrugations on the outer wall, like those of *Ajacicyathellus*, subgenus of *Ajacicyathus* (see Debrenne 1964 : 127), or *Archaeocyathellus* Ford 1873, distinguish it as a subgenus.

DISCUSSION. R. & W. R. Bedford (1937) compared *A. floreus* with *Archaeocyathellus*. They singled out forms with radial imperforate septa and stirrup-pores at the inner wall, from others with regularly porous septa. The holotype of *floreus* (S 4144), the paratype and other material in the B.M. (N.H.) collection, show sparse pores but no stirrup-pores.

The only species recognized at present is *Loculicyathus* (*Loculicyathellus*) *floreus* (R. & W. R. Bedford 1934).

Loculicyathus (*Loculicyathellus*) *floreus* (R. & W. R. Bedford)

(Pl. 3, figs. 1, 2, 4)

1934 *Archaeocyathus floreus* R. & W. R. Bedford : 2, fig. 4.
1937 *Archaeocyathus floreus* R. & W. R. Bedford; R. & J. Bedford : 35, figs. 144A & B.

HOLOTYPE. B.M. (N.H.) S 4144.

OTHER MATERIAL. Paratype B.M. (N.H.) S 4145. Also B.M. (N.H.) S 4730, S 4739 and S 7635.

DIAGNOSIS. Small cylindrical cup with vertical corrugation between two neighbouring septa, so that transverse sections recall scleractinian corolla. Outer wall with horizontal and vertical rows of non-alternating pores. The pores of the inner wall and septa are in quincunx. A few dissepiments occur across the intervallum and central cavity.

DIMENSIONS

	S 4144 (mm.)	S 4145 (mm.)	S 4739 (mm.)
Cup:			
Height (pars)	9·5	10	..
Diameter	low 5·0 upp. 6·0	low 5·0 upp. 6·5	6·77
Interseptum	0·75–2·0	0·75–2·0	0·95
Interv. coeff.	0·4	..	1·6
Parietal coeff.	1·0	..	1·6
Outer Wall:			
No. of pore rows per intersept	6	..	..
Diameter of pores	0·13	..	..
Vertical skel. part.	0·13	..	..
Horizontal skel. part.	0·33	..	..

DIMENSIONS—*continued*

	S 4144 (mm.)	S 4145 (mm.)	S 4739 (mm.)
Inner Wall:			
No. of pore rows per intersept	2	..	..
Diameter of pores	0·23	0·26–0·37	..
Vertical skel. part.	0·33	0·35	..
Horizontal skel. part.	0·23	0·22	..
Septa:			
Diameter of pores	0·23	0·30	..
Vertical skel. part.	0·33	..	..
Horizontal skel. part.	0·23	0·26	..

DISCUSSION. The specimens from Ardrossan figured by R. & J. Bedford, (1939, figs. 144 A & B) only have one pore per intersept at the inner wall and a non-corrugated outer wall. They would therefore, seem to be a quite different form.

Family ***ROBUSTOCYATHIDAE*** Debrenne, 1964

Genus ***ROBUSTOCYATHUS*** Zhuravleva, 1960

TYPE SPECIES. *Archaeocyathus robustus* Vologdin 1937, by original designation of Zhuravleva (1960 : 133).

DIAGNOSIS. Solitary cups with simply porous outer wall and single vertical row of apertures per intersept at the inner wall, so that each loculus opens into the central cavity.

COMPOSITION OF THE GENUS. *R. argentus* (Okulitch 1935), *R. annulatus* Zhuravleva 1960, *R. artecaveatus* (Vologdin 1940*a*), *R. biohermicus* Zhuravleva 1960, *R. densus* Debrenne 1964, *R. hupei* Debrenne 1964, *R. levigatus* (Vologdin 1940*a*), *R. magnipora* (R. & W. R. Bedford 1934), *R. moori* (Vologdin 1937), *R. novus* Zhuravleva 1960, *R. polyseptatus* (Vologdin 1940*a*), *R. proskurjakowi* (von Toll 1889), *R. pseudotichus* (Vologdin 1940*a*), *R. salebrosus* (Vologdin 1931), *R. spinosus* Zhuravleva 1960, *R. subacutus* (R. & W. R. Bedford, 1934), *R. sucharichensis* Zhuravleva 1960, *R. ? tenuis* (Vologdin 1940).

Robustocyathus magnipora (R. & W. R. Bedford)

(Pl. 3, fig. 5)

1934 *Archaeocyathus magnipora* R. & W. R. Bedford : 2, pl. 1, fig. 7.
1937 *Paranacyathus magnipora* (R. & W. R. Bedford) R. & J. Bedford : 34.

HOLOTYPE. B.M. (N.H.) S 4146.

DESCRIPTION. The holotype, a partially destroyed cup, was the only specimen examined. The radial septa are few, straight and pierced by three alternate vertical

rows of circular pores, which are not connected to the wall pores. The outer wall is a thin plate with circular pores in quincunx. The inner wall has a single vertical row of large pores per intersept and pores of neighbouring rows alternate. The septa, which spring out of the inner wall, form boundaries to new pores by splitting the previous one.

DIMENSIONS

	(mm.)
Cup:	
Height (pars)	24
Diameter	8·8
Intervallum	1·83
Interseptum	0·74
Loculus (trapezoid)	0·47 and 0·6 for Height = 0·9
Parietal coefficient	+ unknown
Outer wall:	
Vertical rows of pores per intersept	4
Diameter of pores	0·20
Skeletal partitions	0·13
Thickness	0·13
Inner wall:	1
Vertical diameter	0·40
Horizontal diameter	0·60
Skeletal partitions	0·33
Thickness	0·33
Septa:	
Alternating vertical rows of pores per septum	3
Diameter	0·61
Skeletal partitions	0·61

DISCUSSION. The specimens figured by R. & J. Bedford (1937, figs 142A–E) and described as *magnipora* are unlike the holotype mentioned above. They differ by having various forms and patterns of outer wall and septal pores. These characters, together with the presence of an *Archaeopharetra*-type apex, caused R. & J. Bedford to place *magnipora* in the genus *Paranacyathus*. Unfortunately, it was not possible to compare the holotype with these specimens. The holotype (S 4146) shows the true characters of *Robustocyathus*: regular walls and septal pores, which are sufficient to place it in the Class Regularia, although the initial stages are not present in the specimen. At the moment, it is not possible to decide the true systematic position of the specimens figured by the Bedfords in 1937.

Robustocyathus subacutus (R. & W. R. Bedford)

(Pl. 3, figs. 6, 7, Text-fig. 4)

1934 *Archaeocyathus subacutus* R. & W. R. Bedford : 2, pl. 1, figs. 3a–c.
1937 *Archaeocyathus acutus* Bornemann; Ting : 358, pl. 9, figs. 1–2.
1961 *Ajacicyathus walliseri* F. & M. Debrenne : 696, pl. 19, fig. 3.

HOLOTYPE. B.M. (N.H.) S 4142.

OTHER MATERIAL. B.M. (N.H.) S 4143, S 4747, S 4792, S 7620.

DESCRIPTION. Small cylindrico-conical cup with thin skeletal plates and few pores. The outer wall only has one pore in the middle of each intersept; these pores are arranged in widely separated vertical rows and more closely set horizontal ones. The inner wall is thin and perforated by a single row of pores per intersept. The aperture

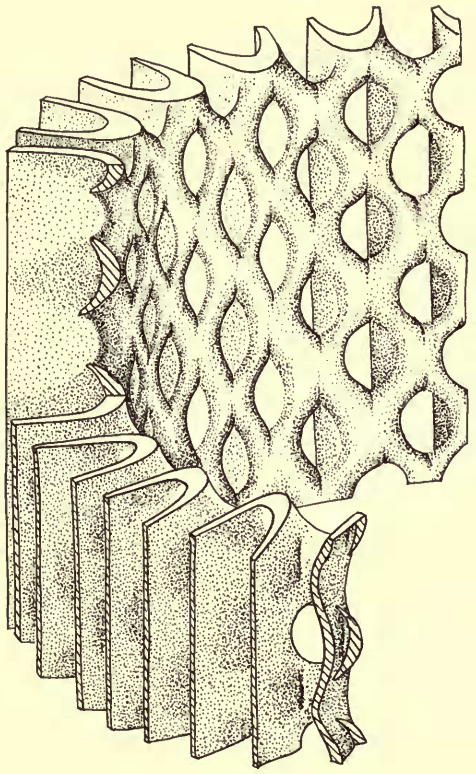

FIG. 4. *Robustocyathus subacutus* (R. & W. R. Bedford)

of each pore is larger than the width of the interseptum. The inner edges of the septa, which laterally delineate the pore, have vertical undulations (see Text-fig. 4). Numerous radial septa, having a few small isolated pores, are found near the outer wall, but they have only been seen in specimen S 4747.

The undulations on the inner edges of the septa, close to the inner wall, are different from those seen in *Ethmophyllum* Meek. The amplitude of the waves is smaller, while the sinuous edges do not join together to close up the interseptum and form another wall that connects the septa, but simply limit the inner wall pores. The inner wall, itself, remains as a completely separate sheet.

DIMENSIONS

	S 4142 (mm.)	S 4143 (mm.)	S 4747 (mm.)	S 7620 (mm.)	*walliseri* (mm.)
Cup:					
Height (pars)	30	20	25	+	+
Diameter	10–12	+	8–10	7	13
Intervallum coeff.	0·3	0·39	0·5	..	0·23
Parietal coeff.	5·4	+	5·5	5·5	5·2
Interseptum	0·30	0·33	0·20	0·25	..
Loculus	1/6	1/8	1/7	..	1/4
Outer wall:					
No. of pore rows per intersept	1	+	+	1	1
Diameter	0·13	..	..	0·7	0·13
Skeletal vert. part.	0·40	..	..	0·40	+
Skeletal horiz. part.	0·13	..	..	0·13	0·11
Thickness	0·06	..	0·06	0·07	0·07
Inner wall:					
No. of pore rows per intersept	1	1	1	1	1
Diameter	0·33	0·40	0·27	0·27	0·26
Skeletal vert. part.	0·13	0·13	+	0·13	0·13
Skeletal horiz. part.	0·13	0·13	+	0·13	+
Thickness	0·33	0·40	0·33	0·27	0·26
Septa					
Thickness	0·10	0·10	+	0·10	0·06

DISCUSSION. *R. walliseri* Debrenne, in spite of its very large size, seems to fall between the limits of specimens of *subacutus*. Another species, *R. pseudotichus* (Vologdin) has similar undulations on the inner parts of the septa that border the large inner wall pores, but in addition, has long spines on the vertical edges of the pores.

Genus ***ZONACYATHUS*** R. & J. Bedford, 1937

1937 *Zonacyathus* R. & J. Bedford : 36.
1940a *Ethmophyllum* Meek; Vologdin (*pars*) : 66–68.

TYPE SPECIES. *Archaeocyathus retevallum* R. & W. R. Bedford (1934 : 2, fig. 6), by monotypy.

DIAGNOSIS. Porous two-walled cups with no, or few, porous radial septa. The outer wall has regular pores. The inner wall has branching pore-tubes; the initial tube is located in the middle of each interseptum and then branches so that the secondary tubes open in front of the septa. The tubes may lengthen and curve into the central cavity. The pore-tubes are never formed by septal fluting.

DISCUSSION. The type species *retevallum* is known from only the three specimens in the B.M. (N.H.) collection. The skeletal tissue is extremely thin and breakable, with the result that structures are either crushed or destroyed, making it difficult to distinguish the pore systems. The validity of a genus based on such fragments may be questionable. Nevertheless, from studying a very close but simpler species, *Z. retezona* Taylor, which has an inner wall built of shorter pore-tubes that branch in the same way, it is possible to understand the more complex pattern present in *retevallum*.

Composition of the Genus. *Zonacyathus retevallum* (R. & W. R. Bedford 1934), *Z. retezona* (Taylor 1910). The species *Ethmophyllum poletevae* Vologdin 1940*a*, *E. vermiculatum* Vologdin 1938 and *E. flexum* Vologdin 1940*a*, are placed in *Zonacyathus* with reservation.

Zonacyathus retevallum (R. & W. R. Bedford)

(Pl. 4, figs. 4, 5)

1934 *Archaeocyathus retevallum* R. & W. R. Bedford : 2, fig. 6.
1937 *Zonacyathus retevallum* (R. & W. R. Bedford,) R. & J. Bedford : 36, figs. 153A–E.
1965 *Zonacyathus retevallum* (R. & W. R. Bedford): Hill : 76, pl. 4, figs. 3a–b.

Holotype. B.M. (N.H.) S 4147.

Other Material. B.M. (N.H.) S 4726–4727.

Description. Bowl-shaped cup with narrow waved intervallum, easily distorted but without giving any obvious folds. Owing to the bad preservation of the material, all measurements are approximate and observations incomplete.

Outer wall simple with two alternating rows of oval pores, arranged in quincunx, to each interseptum. The septa are difficult to see in longitudinal section in the Bedford specimens. The septa appear to be imperforate, but may have small scattered pores. The inner wall has branching pore-tubes of Y-form, which lengthen and curve into the central cavity. It is suspected that some lateral communication occurs between the pore-tubes that penetrate into the central cavity.

Dimensions

	S 4147 : 1 (mm.)	S 4147 : 2 (mm.)	S 4726–4727 (mm.)
Cup:			
Height	25	40	..
Diameter	20	12–30	10
Intervallum coefficient	0·11	0·12	0·2
Parietal coefficient	..	6·6	..
Interseptum	0·27	0·27	0·27
Loculus	1/7·2	1/4·8	1/5·5
Outer wall:			
No. of rows of pores per intersept	2	2	..
Diameter of pores	..	0·13×0·06	..
Vertical partitions	..	0·10	..
Horizontal partitions	..	0·10	..
Thickness	0·10	0·13	0·10
Inner wall:			
No. of rows of pores per intersept	1	1	1
Diameter of pores	0·20	0·27	0·20
Vertical partitions	0·10	0·13	0·13
Horizontal partitions	0·10	0·13	0·13
Thickness	at least 0·6	0·8	0·6
Septa:			
Thickness	..	0·10	0·10

Discussion. *Ethmophyllum flexum* Vologdin (1940*a* : 66, pl. 15, fig. 4) is very similar to *Z. retevallum* R. & W. R., Bedford, having the same irregular shape and size.

Zonacyathus retezona (Taylor)

(Pl. 4, figs. 1, 2, 3, Text-fig. 5)

1910 *Archaeocyathus retezona* (Taylor) : 121, pl. 7, fig. 38A, pl. 6, fig. 31E.

Material. B.M. (N.H.) S 4353, S 4764, S 4774, S 4778, S 4803–4808, S 4811–4816, S 7623, S 7634, S 4731.

Description. Conical, externally smooth cups. The outer wall is a porous sheet, with vertical alternating rows of slightly elliptical pores surrounded by skeletal tissue

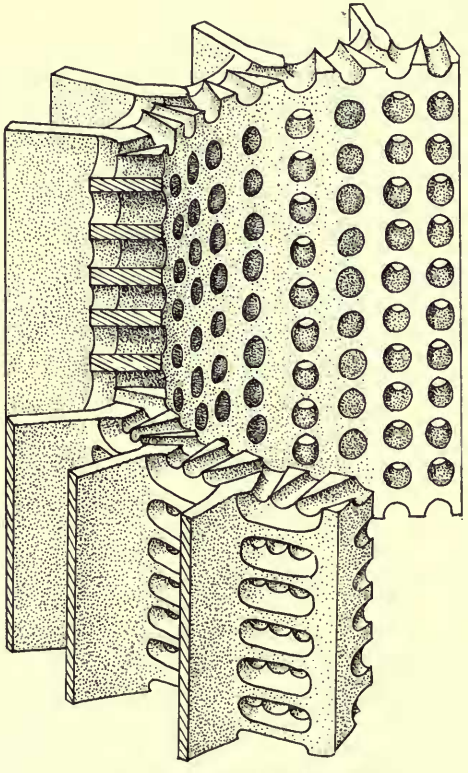

Fig. 5. *Zonacyathus retezona* (Taylor)

of constant width. Radial septa are, probably, imperforate. Inner wall independent from septa and has two vertical rows of pores, one row opposite each septa and the other in the middle of each interseptum. Each pore opposite a septum, is the opening for two oblique pore-tubes, one coming from each loculus. On the inner face of the intervallum, a central, radial pore-tube is joined by a branch from each of its neighbours to form one elliptical pore. All of these pore-tubes are horizontal. *Z. retezona*

differs from *Z. retevallum* because its tubes are short and do not lengthen, or curve into the central cavity.

DIMENSIONS

	S 4353 (mm.)	S 7623 (mm.)	S 4811–4816 (mm.)	S 4730–4732 (mm.)	S 4764 (mm.)	S 4774–4777 (mm.)	S 7634 (mm.)	S 4778 (mm.)
Cup:								
Height	20	..	45	42	20	pars 15	..	13
Diameter	10	8	15	27	5–8	9	10	10
Intervallum coeff.	0·21	0·22	0·12	0·9	0·3	0·25	0·21	0·21
Loculus	1/3	1/3	1/3	1/3	1/2	1/3	1/3	1/3
Parietal coeff.	3·9	4·2	..	..	4·8 to 3·9	..	3·4	..
Outer wall:								
No. or rows of pores per intersept	4	4	3	4	4–6	4–6	4–6	4
Diameter of pores	0·06	..	0·10	0·06	0·07	..	..	0·07
Vertical partitions	0·07	..	0·07	0·06	0·06	..	..	0·05
Horizontal partitions	0·06	..	0·06	0·07	0·06	..	..	..
Thickness	0·13	0·13	0·13	0·13	0·10	..	0·13	..
Inner wall:								
No. of rows of pores per intersept	1	1	1	1	1	1	1	1
Diameter of pores	0·20–0·27	0·27	0·13–0·2	0·27	0·27	..	0·27	0·20
Vertical partitions	0·16	0·13	0·10	0·13	0·13	..	0·16	..
Horizontal partitions	0·13	..	0·13	0·20	0·20	..	..	0·13
Thickness	0·40	0·40	0·35	0·40	0·40	..	0·54	0·40
Septa:								
No. of pore rows	0	..	2	?	1	..	..	..
Diameter of pores	..	..	0·13	0·13	..	..	..	..
Partitions	..	..	0·13	0·33	..	..	..	..
Thickness	0·07	0·10	0·10	0·10	..	..	0·06	0·07

DISCUSSION. Taylor (1910 : 122) gave the following interpretation of the inner wall of *Z. retezona*: " a simply porous inner wall, with one or two pores between each pair of adjacent septa ". In fact, if one refers to his fig. 27, it is seen that one pore occurs in each septum and the other in the middle of the interseptum. I consider that the regular inner wall is composed of pore tubes, that join together and open into the central cavity. Taylor thought the inner parts of the septa were modified into curved rods which supported the simple inner wall. However, the excellent silicified material in the Bedford collection enables the path of the canals to be followed throughout their length.

Family **BRONCHOCYATHIDAE** R. & J. Bedford, 1936

1936 Bronchocyathidae R. & J. Bedford : 25
1937 Stillicidocyathidae Ting : 367.
1951 Thalamocyathidae Zhuravleva : 98.
1955 Ethmophyllidae Okulitch : E 12.
1959 Cyclocyathellidae Zhuravleva : 426.
1965 Bronchocyathidae R. & J. Bedford; Hill : 93.

TYPE GENUS. *Thalamocyathus* Gordon 1920 (=*Bronchocyathus* R. & J. Bedford, 1936).

Composition of Genus. *Thalamocyathus* Gordon 1920, *Stillicidocyathus* Ting 1937. *Polystillicidocyathus* Debrenne 1959, *Cyathocricus* gen. nov.

Remarks. Thalamocyathidae Zhuravleva 1951 has not won general acceptance under Article 40*a* of the International Code of Zoological Nomenclature, 1961 and while this rule stands in its present form, this family name must be rejected.

Genus ***CYATHOCRICUS*** nov.

Type Species. *Archaeocyathus tracheodentatus* R. & W. R. Bedford, 1934.

Derivation. From κρικος, *cricos* = a ring.

Diagnosis. Cup with a simply porous outer wall; straight, sparsely perforated radial septa and an annulate inner wall. Annuli consist of undulating, horizontal, or slightly inclined plates that are neither S-, nor V-shaped; their axial rim is cogged.

Composition of the Genus. *C. tracheodentatus* (R. & W. R. Bedford 1934), *C. dentatus* (Taylor 1910) and *C. annulispinosus* (Vologdin 1931).

Discussion. *Cyathocricus* differs from other annulate genera in that the rings appear to be straight in vertical section. The β component, closest to the septa, is generally horizontal and the α component, projecting into the central cavity, is complicated by cogs that are more or less fused together.

This new genus is established for those species incorrectly referred to the genus *Bronchocyathus* R. & J. Bedford 1936. Hill (1965 : 94) gives an account of this situation, involving *Thalamocyathus* and *Bronchocyathus*.

Gordon (1920 : 687) created the genus *Thalamocyathus* and included the species *Archaeocyathus tubavallum* Taylor, *A. trachealis* Taylor, *A. infundibulum* Bornemann, *A. ichnusae* Meneghini and *T. flexuosus* Gordon, but did not designate a type species.

R. & J. Bedford (1936 : 25) erected *Bronchocyathus*, designating *B. trachealis* (Taylor) as the type species and including *Ethmophyllum dentatum* Taylor and *Archaeocyathus tracheodentatus* R. & W. R. Bedford.

The type species of *Thalamocyathus* Gordon was subsequently designated by Ting (1937 : 368) as *T. trachealis* (Taylor), after elimination of the other syntype species because they possessed cribrose inner walls. Hill (1965 : 94) states that she considers this to be a valid designation. Simon (30th Dec. 1939 : 40) later named *A. trachealis* as the type species of the genus, in case of any doubts that Ting had done so.

Thus *Bronchocyathus* R. & J. Bedford, is a junior objective synonym of *Thalamocyathus* Gordon since both have the same type species (Int. Code Nomen., Article 61b).

R. & J. Bedford (1939 : 75) pointed out that *A. trachealis* Taylor belonged to *Cyclocyathus* Vologdin 1931, a genus of which they were unaware in 1936. As Vologdin had not designated a type species, they cited *trachealis*, but this is not acceptable since the species was not listed in the original description of *Cyclocyathus*, although the Bedfords considered that Vologdin's use of *tubavallum* Taylor was a *lapsus calami* for *trachealis* Taylor. In referring to *tubavallum*, the Bedfords mentioned that it was the first species listed by Gordon in his description of *Thalamocyathus* and was founded on a single fragment of which conflicting figures were provided, and that the whereabouts of the specimen is uncertain. Finally, R. & J.

Bedford (1939 : 75) decided to apply the name *Bronchocyathus* to those forms having a more complex inner wall than *Cyclocyathus* and gave *Ethmophyllum dentatum* Taylor as the type species. This does not conform to the rules of zoological nomenclature, for Article 61 states "the type of any taxon, once fixed in conformity with the provisions of the Code, is not subject to any change except by exercise of the plenary powers of the Commission ". It is, therefore, necessary to provide another name for the genus containing *dentatum* Taylor. *Archaeocyathus tracheodentatus* R. & J. Bedford, is selected as the type species of the new genus *Cyathocricus*, as it is more thoroughly known than *dentatum*.

Hill (1965 : 94) mentions other nomenclatural problems of *Thalamocyathus* and the species *trachealis* Taylor. Zhuravleva (1960 : 220) cites *Bronchocyathus* as the genus of the family Bronchocyathidae, distinguishing this group from the Stillicidocyathidae by the presence of inter-communicating pore-tubes. However, this was based on the use of *E. dentatum* Taylor as type-species of *Bronchocyathus*.

Cyathocricus tracheodentatus (R. & W. R. Bedford)

(Pl. 5, figs. 4, 5, Pl. 6, fig. 4, Text-fig. 6)

1934 *Archaeocyathus tracheodentatus* R. & W. R. Bedford : 2, fig. 5.
1936 *Bronchocyathus tracheodentatus* (R. & W. R. Bedford) R. & J. Bedford : 25, fig. 104.

Holotype. B.M. (N.H.) S 4148.

Other Material. B.M. (N.H.) S 4754.

Description. The type specimen is a conical cup with a broken apex. Corrugations on the upper part provide good tangential and longitudinal sections of the inner wall (see Text-fig. 6). The numerous radial septa are straight and are perforated by a few vertical rows of fine pores. Part of the outer wall is preserved, showing the somewhat irregularly placed polygonal pores. The inner wall consists of a vertical series of thick, horizontal, ring-shaped plates, which are triangular in cross-section and are joined to the inner edges of the septa by the β component. The annuli thin toward the central cavity, are slightly wavy on their upper face and their free rim (α component) is regularly cogged.

Dimensions

	S 4148 (Upper) (mm.)	S 4148 (Lower) (mm.)	S 4754–4755 (mm.)
Cup:			
Height (pars).	31	31	5
Upper Diameter	11	6·5	7
Lower Diameter	0·2	0·3	0·3
Parietal coefficient	..	8·3	..
Interseptum	0·27	0·13	0·13
Loculus	0·27/1·6	0·13/1·29	..
Outer wall:			
No. of pore rows per intersept	3–4	..	2
Diameter	0·06	0·06	0·05
Vertical partitions	0·05	0·05	0·05
Horizontal partitions	0·05	0·05	0·05
Thickness	0·10	0·10	0·13

DIMENSIONS—*continued*

	S 4148 (Upper) (mm.)	S 4148 (Lower) (mm.)	S 4754–4755 (mm.)
Inner wall:			
Space between rings	0·27	..	0·20
Thickness of ring	0·13–0·20	..	0·10
Length of cog	0·67	..	0·67
Width of ring	0·33	..	0·27
Space between cogs	0·5	..	..
Septa:			
No. of pores	Imperforate	..	Imperforate
Thickness	..	0·06	0·05

DISCUSSION. *C. annulispinosus* (Vologdin 1931) is similar morphologically, but its specific coefficients are not well known. According to Vologdin (1931 : fig. 42) the diameter is approximately 5·6 mm, the intervallum coefficient would be 0·4 and the parietal coefficient 12—figures that are quite close to those of specimen S 4148. The essential difference is in the downward orientation of the annuli into the central cavity present in *annulispinosus*.

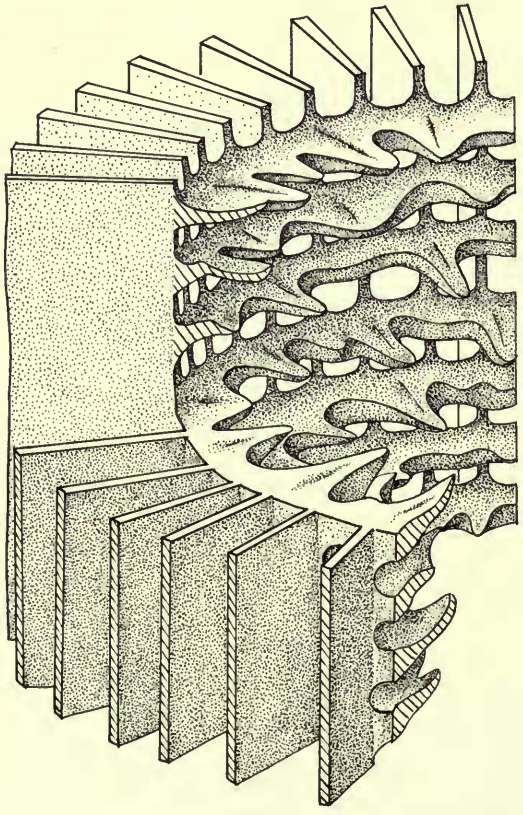

FIG. 6. *Cyathocricus tracheodentatus* (R. & W. R. Bedford)

Cyathocricus dentatus (Taylor)

(Pl. 6, figs. 1–3, Text-fig. 7)

1910 *Ethmophyllum dentatum* Taylor : 129, pl. 10, fig. 59; pl. 13, fig. 76; pl. 16, fig. 89; t.-figs. 23 and 31.
1936 *Bronchocyathus dentatus* (Taylor) R. & J. Bedford : 25, fig. 103.
1960 *Bronchocyathus dentatus* (Taylor); F. & M. Debrenne : 703, pl. 20, fig. 8.

HOLOTYPE. Not designated.

OTHER MATERIAL. B.M. (N.H.) S 4752–4753, S 4756, S 4355.

DESCRIPTION. Cylindrical-conical cup that may have a large diameter and a wide central cavity. The intervallum is full of straight radial septa, that have about 2–3 vertical rows of small pores near the outer wall. The outer wall is perforated by pores of the same size as those of the septa, with 2–3 alternate vertical rows per interseptum. There are no stirrup-pores connecting the two systems. The inner wall is formed by a series of vertical annular plates, which are as thick as the septa. These plates extend into the inner part of the intervallum, as well as into the central cavity.

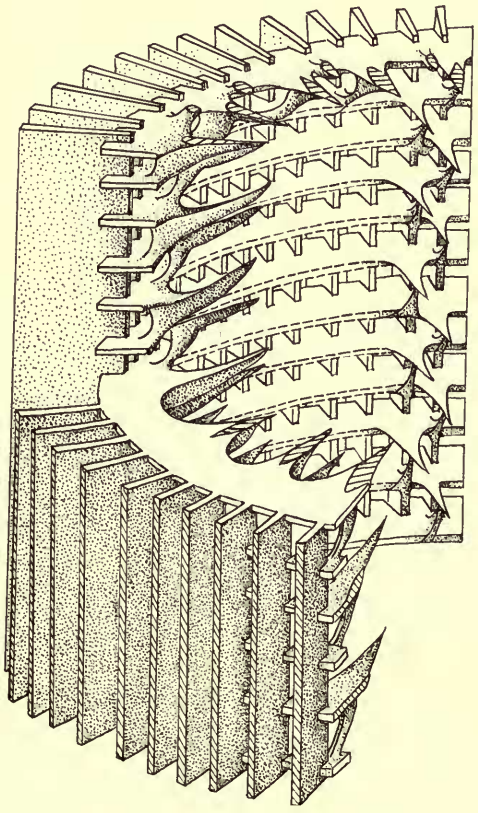

FIG. 7. *Cyathocricus dentatus* (Taylor)

Their free edge is serrated into toothlike projections, that are 2–3 loculi wide at the base, and which are situated either in front of a septum, or in the centre of an intersceptum (Pl. 6, fig. 2). The tips of these projections are flat on top and bend slightly upwards. When examining the material, layers of the teeth were prised apart without discovering any order of appearance. On the lower part of each tooth there is a curved support which joins it to the underlying ring plate.

DIMENSIONS

	S 4355 (mm.)	S 4753 (mm.)	S 4756 (mm.)	S 4752 (mm.)
Cup:				
Height	17	30	53	..
Diameter	12	18	15–16	9
Intervallum coefficient	0·3	0·15	0·5	..
Interseptum	0·13	0·20	..	0·13
Outer wall:				
No. of pore rows per intersept	2	2–3	not seen	..
Diameter	0·06	0·06	..	..
Vertical partitions	0·05	0·05	..	..
Horizontal partitions	0·05	0·05	..	..
Thickness	0·06	0·06	0·06	0·13
Inner wall:				
Distance between annuli	0·20	0·27	0·20	0·20
Thickness of annuli	0·06	0·06	0·06	0·10
Width of annuli	0·40	0·33	0·27	0·33
Projections	0·40	0·67	0·27	0·67
Septa:	Imperforate	Perforate on outer side	Imperforate	
Thickness	0·06	0·06	..	0·05
Diameter	..	0·06	..	..
Vertical partitions	..	0·06	..	..
Horizontal partitions	..	0·27	..	..

DISCUSSION. The interpretation of the inner wall structure of *dentatus* is difficult owing to the limited number of known specimens. In common with other forms, the term " vesicular " has been used in the past to describe the various poor oblique sections of specimens, which have a complex inner wall structure. It was not possible to examine the holotype, but there are specimens of *dentatus* in the Bedford collection, wrongly called *tracheodentatus*, which provided various views of this structure. From these specimens (S 4355, S 4753 and S 4752) it was possible for me to reconstruct the inner wall of *dentatus* with some certainty. This species differs from *tracheodentatus* and *annulispinosus* by having thinner annuli, vertical supports between the annuli, and the triangular shape and different distribution of the teeth.

Family **ETHMOCYATHIDAE** nov.

DIAGNOSIS. Simple outer wall; uniserially pored inner wall covered over on the innermost (central cavity) side with a secondary wall of annular plates. This feature is characteristic of the new family. *Ethmocyathus* R. & W. R. Bedford is the type genus.

Discussion. It is necessary to create a separate family within the Ajacicyathacea to place the genus *Ethmocyathus*. There is no justification for placing *Ethmocyathus* in the family Ethmophyllidae (Hill 1965 : 76; Zhuravleva 1960 : 162), for its inner wall is not formed by horizontal fluting of the inner edges of the septa, as they suggested. Neither is the genus a doubtful member of the Tumulocyathidae (Debrenne 1964 : 113), since the outer wall has simple pores and its annuli have a peculiar form.

Genus ***ETHMOCYATHUS*** R. & W. R. Bedford, 1934

1934 *Ethmocyathus* R. & W. R. Bedford : 2, fig. 8.

Type Species. *Ethmocyathus lineatus* R. & W. R. Bedford, by monotypy.

Description. Cup with straight radial, sparsely porous septa. The outer wall has close, simple pores. The inner wall is composed of a thin sheet of hexagonal pores screened from the central cavity by thin, narrow horizontal annuli.

Discussion. Sometimes, both of the horizontal sides of the inner wall hexagonal pores are reduced so that the openings become rhombic. The inner edges of the septa are sinuous, following the outlines of the inner wall pores, but do not contribute to their formation by horizontal fluting.

Composition of the Genus. *Ethmocyathus lineatus* R. & W. R. Bedford.

Ethmocyathus lineatus R. & W. R. Bedford

(Pl. 5, figs., 1–3, Text-fig. 8)

1934 *Ethmocyathus lineatus* R. & W .R. Bedford : 2, fig. 8.
1965 *Ethmocyathus lineatus* R. & W. R. Bedford; Hill : 76, pl. 4, figs. 2a–b, t.-fig. 16. 2.

Holotype. B.M. (N.H.) S 4149.

Description. This is based on a single specimen consisting of a fragment from a, probably, cylindrical cup. Radial septa with sparse pores on the outer two-thirds of each septum. The annular plates join the inner wall net of hexagonal pores, without any visible thickening. The outer wall is simple with regular oval pores.

Dimensions

	(mm.)
Cup:	
Height (pars).	15
Diameter (approx.)	13
Interseptum	0·18
Intervallum coefficient	0·13
Outer wall: (only seen between 2 neighbouring septa)	
3 pores lengthened horizontally and arranged in quincunx	
Diameter	0·05–0·03
Skeletal partitions	0·03
Thickness	0·07

DIMENSIONS—*continued*

	(mm.)
Inner wall:	
Vertical diameter	0·27
Horizontal diameter	0·2
Skeletal partitions	0·075
Thickness	0·37
Thickness of annuli	0·03
Distance between annuli	0·03
5 annular plates cover one pore (vertically)	
Septa:	
Imperforate for 0·37 mm. from the inner wall	
Diameter of pores	0·03
Vertical partitions	0·15
Horizontal partitions	0·18

DISCUSSION. Only this one species known.

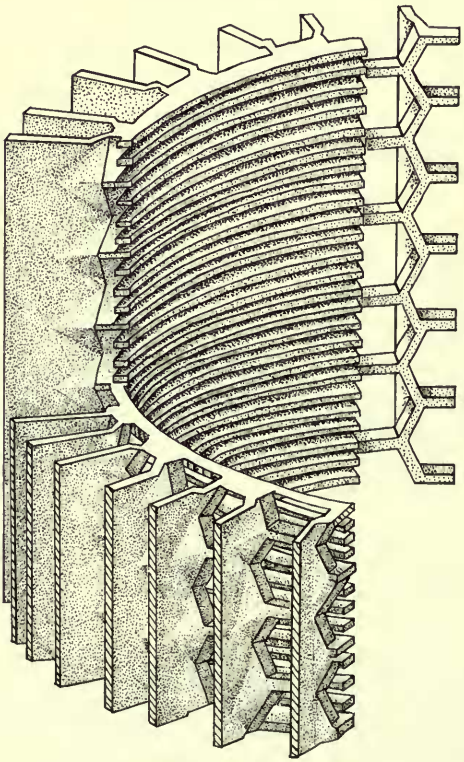

FIG. 8. *Ethmocyathus lineatus* R. & W. R. Bedford

Family **ERISMACOSCINIDAE** Debrenne, 1964

Diagnosis. Cup with radial septa and porous tabulae. Thin, simply porous outer wall. Inner wall with several vertical series of pores to each interseptum, sometimes with thickening of the pore framework (" linteaux ") and ornamental spines.

Composition of the Family. *Erismacoscinus* (*Pluralicoscinus*) Debrenne 1963, *Erismacoscinus* Debrenne 1958, *Asterocyathus* Vologdin 1940, *Retecoscinus* Zhuravleva 1960, *Tuvacyathus* Vologdin 1940, *Geniculicyathus* Debrenne 1960, *Coscinoteichus* Debrenne 1964, *Coscinoptycta* Broili 1915.

Genus ***ERISMACOSCINUS*** Debrenne, 1958

Type Species. *Erismacoscinus marocanus* Debrenne 1958 : 65, pl. 3, figs. 11–16, by monotypy.

Diagnosis. Intervallum with regularly porous septa and tabulae. Simple outer wall, generally perforated by numerous openings in quincunx. Thick inner wall, always has several vertical series of pores to each interseptum. The inner wall pores frequently carry spines, that vary in shape and distribution.

Composition of the Genus. *Erismacoscinus* contains all those species, having several vertical series of pores to each interseptum, that were previously included in the genus *Coscinocyathus* Bornemann (see list of Debrenne 1964 : 166–167).

Discussion. Hill (1965 : 108–109) suggests this genus might be synonymous with *Tannuolacyathus* Vologdin 1957, but the vesicular tissue and double porous wall of the latter, have led me to consider that genus as belonging to a distinct family, the *Tannuolacyathidae* (Debrenne 1964 : 188).

Erismacoscinus rugosus (R. & W. R. Bedford)

(Pl. 8, figs. 2, 3)

1934 *Coscinocyathus rugosus* R. & W. R. Bedford : 3, fig. 11.
1964 *Erismacoscinus rugosus* (R. & W. R. Bedford) Debrenne : 167.

Holotype. B.M. (N.H.) S 4152.

Description. A single specimen of a funnel-shaped cup with a wide intervallum and rather narrow central cavity. Septa simply porous and not always reaching the inner wall. Tabulae form a regular network of pores. The inner wall is simple with some spines. The pores of the outer wall are in vertical rows, between which the " linteaux " project. These keels continue towards the exterior, giving the fossil a rough appearance from which its specific name is derived. The pores of neighbouring rows alternate slightly.

DIMENSIONS

	(mm.)
Cup:	
Height (pars).	6
Diameter	from 4·75–5·5
Interseptum (outer)	1·01
(inner)	0·33
Intertabulum	1·35
Loculi	1/2, 8/2, 8
Intervallum coefficient	0·8
Parietal coefficient	3·6
Outer wall:	
2–3 rows of pores per interseptum	
Vertical diameter of pores	0·20
Horizontal diameter of pores	0·30
Vertical thickness	0·13
Horizontal thickness	0·05
Inner wall:	
2 rows of alternating pores per interseptum	
Diameter of pores	0·10
Linteaux	0·16
Thickness of wall	0·10
Septa:	
10 rows of pores per septum	
Diameter of pores	0·05
Partitions	0·15
Tabulae:	
7 pores per interseptum	
Diameter of pores	0·05
Skeletal partitions	0·06

DISCUSSION. The presence of outer keels is a rare modification. It seems that *E. equivallum* (Taylor) has outer keels in front of each septum (see below).

Erismacoscinus equivallum (Taylor)

(Pl. 7, figs. 1–3 and 5)

1908 "turbinate Archaeocyathinoid" Taylor : 426, pl. 1, fig. 1.
1910 *Coscinocyathus equivallum* Taylor : 138–139, pl. 15, fig. 85, t.-fig. 12.
1964 *Erismacoscinus equivallum* (Taylor) Debrenne : 167

HOLOTYPE. In the University of Adelaide.

OTHER MATERIAL. B.M. (N.H.) S 200 is the counterpart (i.e. the other face of the section) of the holotype. S 198, naturally etched specimen figured by Taylor (1908, pl. 1, fig. 2 : 423).

DESCRIPTION. Outer wall has projections of skeletal tissue corresponding to the septa. As I did not see a specimen entirely free of matrix, it is only possible to assume that this feature is similar to the keels present in *E. rugosus*. These projec-

tions only occur at the junction of the septa and the outer wall, and not between the rows of pores in the interseptum. The pores are elliptical and in quincunx.

The inner wall has round, alternate pores. The linteaux are smooth on the intervallum side but small projections of spines and " bristles " occur on the central cavity face.

Thick, straight septa have round regularly scattered pores in elongated quincunx. The skeletal tissue occupies a greater surface area than the pores. Slightly convex tabulae have a fine network of small, more or less regular polygonal pores.

DIMENSIONS

	S 200 (mm.)	S 198 (mm.)
Cup:		
Height	22	..
Diameter	10	30–18
Intervallum coefficient	0·46	0·43
Parietal coefficient	Not measurable	66
Interseptum	0·37	0·41
Intertabulum	0·44	..
Outer wall:		
No. of pore rows per intersept	2	2
Diameter of pores	0·15	0·22–0·15
Vertical partitions	0·11	0·11–0·15
Horizontal partitions	0·15	0·11
Thickness	0·11	0·11
Inner wall:		
No. of pore rows per intersept	2	2
Diameter of pores	0·07	0·15
Vertical partitions	0·07	0·11
Horizontal partitions	0·07	0·11
Thickness	0·11	0·11
Septa:		
No. of pore rows per intersept	9–10	15
Diameter of pores	0·11	0·07
Vertical partitions	0·15	0·22
Horizontal partitions	0·15	0·22
Thickness	0·07	0·15
Tabulae:		
No. of pore rows per intersept	14	4–22
Diameter of pores	0·05	0·05–0·15
Vertical partitions	0·05	0·03–0·07
Horizontal partitions	0·05	..
Thickness	0·07	0·07

DISCUSSION. Specimen S 198 is somewhat corrugated. At the level of the folds the septa are not radial but parallel, as seen in *Polystillicidocyathus* Debrenne and other colonial forms.

The similarity in structure of the two walls is not quite so evident as Taylor stated (1910 : 138). The specimen S 200 shows that the inner wall is a little thinner and has ragged " linteaux " and spines.

Erismacoscinus quadratus (R. & W. R. Bedford)

(Pl. 7, fig. 4, Pl. 8, fig. 5)

1934 *Coscinocyathus quadratus* R. & W. R. Bedford : 3, pl. 2, fig. 10.
1964 *Erismacoscinus quadratus* (R. & W. R. Bedford) Debrenne : 167.

HOLOTYPE. B.M. (N.H.) S 4157.

DESCRIPTION. Only one incomplete specimen known; a little deformed and therefore, difficult to measure accurately or to calculate the specific coefficients.

The septa and tabulae form a sub-quadrate network of irregular shape, due to the slight waving of the intervallum plates. They both have isolated, simple, round pores arranged in quincunx. The outer wall also has simple pores in quincunx but with the majority often lengthened horizontally. The inner wall is smooth on the intervallum side, but irregular and with spines around the pores on the central cavity face. The pores are arranged in horizontal rows and alternate from one row to another.

DIMENSIONS

	Lower section (mm.)	Upper section (mm.)
Cup:		
Height	25	
Diameter	11	16
Intervallum	2·64	2·64
Interseptum	0·37–0·50	0·37
Intertabulum	0·30–0·60	..
Intervallum coefficient	0·38	0·2
Parietal coefficient	probably 3·1	..
Outer wall:		
3–4 rows of pores per intersept		
Diameter of pores	0·07–0·15	..
Partitions	0·11	..
Thickness	0·05	..
Inner wall:		
2–3 rows of pores per intersept		
Diameter of pores	0·11–0·13	..
Septa:		
20 pores per loculus		
Diameter of pores	0·03	..
Partitions	0·11	..
Thickness	0·05	..
Tabulae:		
3 rows of 20 pores per loculus		
Diameter of pores	0·03	..
Partitions	0·06	..
Thickness	0·15 (with the spines)	..

DISCUSSION. The peculiar features of the inner wall (smooth in the intervallum, spined in the central cavity) have previously been described for *E. rugosus* (R. & W. R. Bedford) and *E. equivallum* (Taylor)—two species that differ from *quadratus* in other characters.

Okulitch (1948 : 343) compared *rhyacoensis* and *quadratus*, as both have subquadrate loculi. However, the American species has pore-tubes in the outer wall; an inner wall which is typical of *Coscinocyathus*, with a single pore series to each interseptum; and an intervallum with vesicular tissue as well as tabulae.

Erismacoscinus textilis (R. & W. R. Bedford)

(Pl. 9, figs. 1–4)

1934 *Coscinocyathus textilis* R. & W. R. Bedford : 3, pl. 2, below fig. 11.
1964 *Erismacoscinus textilis* (R. & W. R. Bedford) Debrenne : 167.

Holotype. B.M. (N.H.) S 4155.

Paratype. B.M. (N.H.) S 4156.

Description. The holotype has a cylindro-conical cap that tapers gently in its lower parts. The intervallum consists of quadrate to rectangular loculi, limited by radial septa and flat, irregularly-spaced tabulae.

The outer wall has a single vertical series of pores per interseptum (in a large interseptum there are two rows, but these soon become separated by a new septum). The pores of the outer wall are much larger than those of the inner wall, they are also horizontally lengthened and the rows alternate. Pores of the inner wall are very small and arranged in quincunx. Septa and tabulae are regularly porous. Skeletal tissue is well-developed.

The paratype is a fragment of a large, bell-shaped cup, with a narrow intervallum in which the different pore characters of the two walls can easily be compared. The inner wall has a regular net of round pores in quincunx, whilst the outer wall has 1–2 rows of pores. Domes of vesicular tissue are present in several loculi.

Dimensions

	S 4155 (Upper) (mm.)	S 4155 (Lower) (mm.)	S 4156 (mm.)
Cup:			
Height:		30	43
Diameter	10	6	36 (Chord)
Intervallum	1·32	1·32	2
Interseptum	0·40	0·35	0·62
Intertabulum	0·6–2·71	irregular	2·70–4·70
Parietal coefficient	4·2	3·3	..
Outer wall:			
No. of rows of pores per interseptum	1–2	1–2	1–2
Diameter	0·34–0·15	0·34–0·15	0·15
Skeletal partitions	0·11	0·11	0·15
Horizontal partitions	0·07	..	0·15
Thickness	0·95	..	0·15
Inner wall:			
No. of pore rows per interseptum	3–4	..	4
Diameter	0·07	..	0·10
Vertical partitions	0·07	..	0·10
Horizontal partitions	0·07	..	0·10
Thickness	0·11	.	0·07

DIMENSIONS—*continued*

	S 4155 (Upper) (mm.)	S 4155 (Lower) (mm.)	S 4156 (mm.)
Septa:			
No. of rows of pores	8	..	10
Diameter	0·11	..	0·10
Vertical partitions	0·15	..	0·10
Thickness	0·07	..	0·10
Tabulae:			
No. of pores per interseptum	4–5	4	5
Diameter	0·07	0·07	0·05
Vertical partitions	0·07	0·07	0·07
Horizontal partitions	..	..	0·07
Thickness	0·05	0·05	0·10
Vesicular tissue:	..	..	0·03

DISCUSSION. The two specimens, a cylindrical one and a bowl-shaped one, are placed in the same species. More material is needed in order to decide whether they belong to separate species, or not. Generally the outer wall of Archaeocyatha is thinner than the inner one. However, in this species the opposite is the case. It is impossible to recognize the correct position of a fragment, if one only has the pore characters of a wall to go by. Another example of this difficulty is the case of *Coscinocyathus unilinearis* R. & W. R. Bedford (see Pl. 13, fig. 4), and *Coscinoptycta convoluta* (Taylor). If the wall with a single pore, is the inner wall, then *Coscinoptycta* is a synonym of *Coscinocyathus* and *unilinearis* is a species of *Coscinocyathus*. On the other hand, if it is the outer wall that has one pore, then *Coscinoptycta* remains a separate genus and *unilinearis* is a species of *Erismacoscinus*.

Erismacoscinus cellularis (R. & W. R. Bedford)

(Pl. 8, figs. 1 and 4)

1934 *Coscinocyathus cellularis* R. & W. R. Bedford : 3, pl. 3, fig. 16.

HOLOTYPE. S 4162 B.M. (N.H.).

DESCRIPTION. The holotype is a longitudinally broken fragment of an almost cylindrical cup, showing the porosity of the different skeletal plates.

The outer wall is a thin, regular and finely porous plate with horizontally elongated pores. The inner wall is thicker, consisting of small, regular polygonal tubes that face upwards; its central cavity face has several spines, or other outgrowths, arising from the pore walls.

The septa have small evenly-spaced pores. The tabulae are close together with their convex side uppermost, they are also finely perforated but the pores are more numerous than those of the septa.

DIMENSIONS

	(mm.)
Cup:	
Height	55
Diameter	20
Intervallum	3
Intertabulum	1–1·32
Interseptum	0·30
Intervallum coefficient	0·75
Parietal coefficient	not measurable
Outer wall:	
No. of pore rows per interseptum	2
Diameter	0·15–0·07
Vertical partitions	0·07
Horizontal partitions	0·11
Thickness	0·07
Inner wall:	
No. of pore rows per interseptum	3
Diameter	0·15; 0·11; 0·11 (nr. central cavity)
Vertical partitions	0·11
Thickness	0·26
Septa:	
No. of pore rows per interseptum	30 approx.
Diameter	0·03
Vertical partitions	0·11
Horizontal partitions	0·08
Thickness	0·07
Tabulae:	
No. of pore rows per interseptum	3–4
Diameter	0·05
Vertical partitions	0·07
Horizontal partitions	0·07
Thickness	0·07

DISCUSSION. R. & W. R. Bedford (1934 : 3) suggested that the outer wall is covered by a thin membrane that has very minute pores, but I could not find any evidence of this structure. Their " irregular mosaic " of the inner wall is, in fact, the result of the modification of the skeletal tissue (" linteaux ") into barbs and spines. The regular polygonal tubes can be seen on the intervallum face of the inner wall, as in *E. rugosus* and *E. equivallum*.

Erismacoscinus petersi (R. & W. R. Bedford)

(Pl. 10, figs. 4 and 5)

1934 *Coscinocyathus petersi* R. & W. R. Bedford : 3, pl. 3, fig. 13.

HOLOTYPE. B.M. (N.H.) S 4158.

DESCRIPTION. The holotype is a unique, small, well-preserved specimen. The outer wall is simply porous with prominent, sharply-ridged, vertical crests between the septa. The inner wall is a skeletal plate that is perforated by vertical and horizontal rows of regular pores. Consequently, the wall tissue between neighbouring

horizontal rows of pores, forms a continuous circular bar. A small tongue-like plate arises from the bar under each pore, but it was not possible to discover whether these tongues are separate from each other, or connected to form an annular ring. The radial septa have scattered regular pores, while the tabulae consist of a thin porous net.

DIMENSIONS

	(mm.)
Cup:	
Height	9
Diameter	9
Intervallum	1·51
Interseptum (outer wall)	0·83
(inner wall)	0·56
Intervallum coefficient	0·25
Parietal coefficient	2
Outer wall:	
8 pores (4+4) per interseptum	..
Diameter of pores	0·07
Thickness of linteaux	0·07
Thickness of wall	0·11
Inner wall:	
No. of rows of pores per interseptum	2
Diameter of pores	0·07
Vertical partitions	0·11
Horizontal partitions	0·07
Thickness of wall	0·26
Septa:	
No. of rows of pores per septa	6
Diameter of pores	0·03
Vertical partitions	0·11
Horizontal partitions	0·11–0·26
Tabulae:	
No. of rows of pores per interseptum	12
Diameter of pores	0·03
Partitions	0·11

DISCUSSION. The horizontal alignment of the inner wall pores is an important feature, that is a precursor to the formation of annular structures. This is evident in this case, for the horizontal bars are already slightly modified by supplementary plates. However, as the stage of a single pore per interseptum has not been reached, this species should be retained in *Erismacoscinus* and not placed in a genus of the Salairocyathidae. The star-shaped form of the external wall is similar to that of *E. cancellatus* (Bornemann), but the two species have no other features in common.

Erismacoscinus retifer (R. & W. R. Bedford)

(Pl. 10, figs. 2 and 3)

1934 *Coscinocyathus retifer* R. & W. R. Bedford : 3, pl. 3, fig. 14.
1964 *Erismacoscinus retifer* (R. & W. R. Bedford) Debrenne : 167.

HOLOTYPE. B.M. (N.H.) S 4159.

Description. The species is based on a single, small, incomplete specimen, but it is sufficiently well-preserved to enable one to see the details of each skeletal plate. The thin outer wall is perforated by 4–5 vertical rows of pores to each interseptum, these pores also form horizontal rows. The septa and the only visible tabula are of the same thickness as the outer wall, and have their round pores arranged in quincunx; the skeletal tissue between them is wider than the pores and projects slightly.

The inner wall is thicker than the other plates. The pores are elliptical, with the larger diameter horizontal and a tongue arising under each pore. One vertical row of pores is only just separated from the next and, at times, pores from neighbouring rows may join, giving a single pore at that point of the interseptum. At certain places, the pores are aligned horizontally and this involves two sporadic modifications. Firstly, the coalescence of two neighbouring pores, which predicts the uniserially-pored inner wall. Secondly, the development of small tongue-like plates under the pores, forecasting the formation of annular plates.

Dimensions

	(mm.)
Cup:	
Height (*pars*)	9
Diameter	8
Intervallum	1·96
Intervallum coefficient	0·5
Parietal coefficient	3·5
Outer wall:	
No. of pore rows per interseptum	4–5
Diameter of pores	0·07
Vertical partitions	0·10
Horizontal partitions	0·10
Thickness	0·13
Inner wall:	
Diameter of pores	0·28–0·18
Vertical partitions	0·10
Horizontal partitions	0·15
Length of plates	0·20
Septa:	
No. of pores per loculus	9–10
Diameter of pores	0·11
Distance between horizontal rows	0·18
Distance between vertical rows	0.22
Tabulae:	
No. of pores per interseptum	6
Diameter	0·04
Partitions	0·05
Thickness	0·05

Discussion. This species continues to follow the evolution already outlined under *E. petersi* and heralds the annular forms of Salairocyathidae.

Family **POLYCOSCINIDAE** Debrenne, 1964

DIAGNOSIS. Cup with porous septa and tabulae. Double, porous outer wall. Simple inner wall.

COMPOSITION OF THE FAMILY. *Polycoscinus* R. & J. Bedford 1937, *Tomocyathus* Rozanov 1960

Genus ***TOMOCYATHUS*** Rozanov, 1960

1960 *Tomocyathus* Rozanov : 664, figs. 1 d, e.
1964 *Tomocyathus* Rozanov; Debrenne : 115
1964 *Tomocyathus* Rozanov; Repina *et al.* : 231.
1965 *Tomocyathus* Rozanov; Hill : 107

TYPE SPECIES. *Tomocyathus operosus* Rozanov 1960, by original designation.

DIAGNOSIS. Outer wall coarsely porous, covered by a secondary micro-porous sheath. Straight septa and convex tabulae, both with numerous fine pores. Vesicular tissue. Inner wall with simple pores, and stellate in transverse section.

DISCUSSION. The fluting of the walls is often considered a character of subgeneric value (Krasnopeeva 1955; Debrenne 1964). Recently, Repina *et al* (1964 : 231) described *Tomocyathus* without any mention of the stellate inner wall. Some species that they included in this genus, *compositus* (Zhuravleva) and *shoriensis* Rozanov, have little to no vesicular tissue, rather flat tabulae and the inner wall is not fluted but possesses spines of varying size and shape.

According to criteria used in distinguishing other subgenera e.g. *Ajacicyathus* (*Urcyathus*) Vologdin, one must create a new subgenus for the smooth forms of *Tomocyathus*.

COMPOSITION OF THE GENUS. *Tomocyathus* (*Tomocyathus*) *operosus* Rozanov 1960, *T.* (*Tomocyathus*) *michniaki* Rozanov 1966; for subgenus *Tomocyathus* (*Erugatocyathus*) see below.

Subgenus ***ERUGATOCYATHUS*** nov.

DERIVATION. *erugatus* = unfolded.

TYPE SPECIES. *Coscinocyathus papillatus* R. & W. R. Bedford, designated here.

DIAGNOSIS. *Tomocyathus* with non-folded inner wall.

COMPOSITION OF THE SUBGENUS. *Tomocyathus* (*Erugatocyathus*) *echinus* (Debrenne 1964), *T.* (*E.*) *compositus* Zhuravleva 1955, *T.* (*E.*) *gini* Missarzhevsky & Rozanov 1962, *T.* (*E.*) *kundatus* Rozanov 1966, *T.* (*E.*) *shoriensis* Rozanov 1964, *T.* (*E.*) *papillatus* (R. & W. R. Bedford 1934).

Tomocyathus* (*Erugatocyathus*) *papillatus (R. & W. R. Bedford)

(Pl. 11, fig. 2, Text-fig. 9)

1934 *Coscinocyathus papillatus* R. & W. R. Bedford : 3, pl. 3, fig. 12.
1964 *Erismacoscinus papillatus* (R. & W. R. Bedford) Debrenne : 167

HOLOTYPE. B.M. (N.H.) S 4153.

PARATYPE. B.M. (N.H.) S 4154.

DESCRIPTION. Fragments of cylindrico-conical fossils. Septa with remote round pores. Tabulae reticular. Loculi rectangular and irregular in size. The circular pores at the base of the coarsely-porous outer wall are covered by a microporous sheath, in which each group of micropores consists of a central pore surrounded by five others.

A skeletal tongue covers each simple pore of the inner wall, it arises under the pore, curves upwards and rejoins the wall above. As the rows of pores alternate, each pore is surrounded by 4 knobs, corresponding to the beginning of a papilla. This feature is well shown in the weathered specimen S 4154 (see Text-fig. 9).

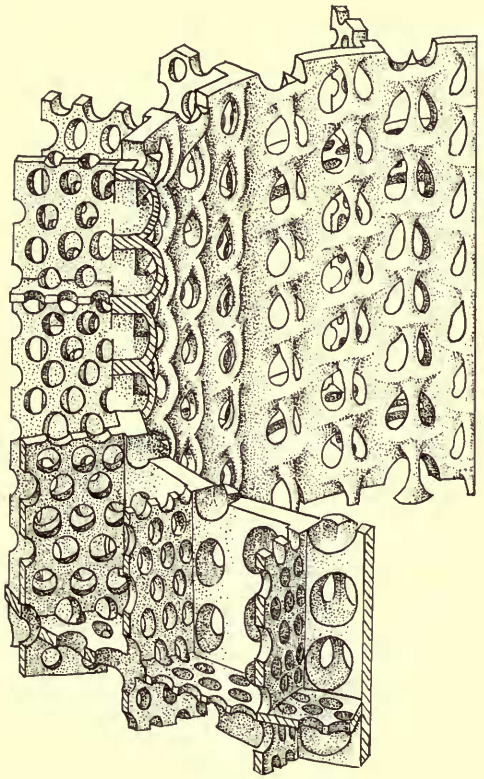

FIG. 9. *Tomocyathus* (*Erugatocyathus*) *papillatus* (R. & W. R. Bedford)

DIMENSIONS

	S 4153 Upper (mm.)	S 4153 Lower (mm.)	S 4154 (mm.)
Cup:			
Height	20		18
Diameter	13	8	10·5
Intervallum coefficient	1·89	1·5	..
Parietal coefficient	3·8	..	..
Intervallum	0·40	0·34	0·41
Interseptum	..	..	2·5–4

DIMENSIONS—*continued*

	S 4153 Upper (mm.)	S4153 Lower (mm.)	S 4154 (mm.)
Outer wall:			
No. of rows of pores per interseptum	..	2	2
Diameter	0·15	0·15–0·03	0·18
Vertical skeletal partitions	0·15–0·18	0·15–0·03	0·15
Horizontal skeletal partitions	..	0·15–0·03	0·15
Thickness	0·15	0·11	..
Inner wall:			
No. of pore rows per interseptum	2	2	2
Diameter	0·22	0·20	0·20
Vertical skeletal partitions	0·15	..	..
Horizontal skeletal partitions	0·15	..	..
Thickness	0·10+pap. = 0·11	0·22	..
Septa:			
No. of pore rows per intervallum	10	8	..
Diameter	0·05	0·07	0·07
Vertical skeletal partitions	0·10	0·11	0·11
Horizontal skeletal partitions	..	..	0·11
Thickness	0·07	0·07	0·07
Tabulae			
No. of pore rows per interseptum	5–6	4–5	4
Diameter	0·05	0·05	0·07
Vertical skeletal partitions	0·07	0·05	0·07
Thickness	0·05	0·05	0·05

DISCUSSION. These peculiar curved tongues are not known in any other species of the Regularia.

Family **SALAIROCYATHIDAE** Zhuravleva, 1955

DIAGNOSIS. Cups with intervallum crossed by porous septa and tabulae. Simple outer wall, but annular inner wall.

COMPOSITION OF THE FAMILY. *Salairocyathus* (*Salairocyathus*) Vologdin 1940, *Salairocyathus* (*Polystillicidocyathus*) Debrenne 1959.

Genus ***SALAIROCYATHUS*** Vologdin, 1940

1940a *Salairocyathus* Vologdin : 89

TYPE SPECIES. *Salairocyathus zenkovae* Vologdin 1940: 89, pl. 26, fig. 6.

DIAGNOSIS. Simple pores in outer wall and also in septa and tabulae. Annuli on inner wall, v-shaped in section and open towards the top.

COMPOSITION OF THE GENUS. *Salairocyathus* (*Salairocyathus*) *zenkovae* Vologdin 1940, *S.* (*S.*) *pospelovi* Zhuravleva 1960, ? *S.* (*S.*) *annulatus* (R. & W. R. Bedford 1934). *Salairocyathus* (*Polystillicidocyathus*) *erbosimilis* Debrenne 1959.

? *Salairocyathus* (*Salairocyathus*) *annulatus* (R. & W. R. Bedford)

(Pl. 11, fig. 4, Text-fig. 10)

1934 *Coscinocyathus annulatus* R. & W. R. Bedford : 4, pl. 3, fig. 17.

Holotype. S 4163 in British Museum (Natural History).

Description. A unique, very fragmentary specimen, that has part of the inner wall, as seen from the central cavity, well preserved. Porous outer wall, but not

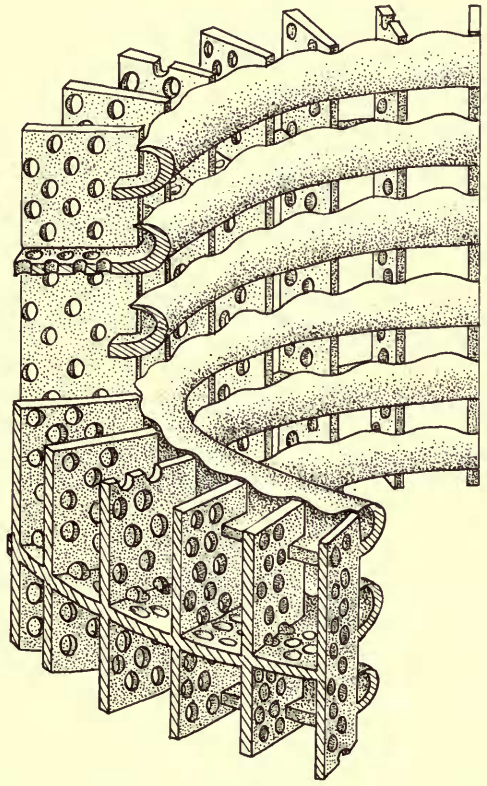

Fig. 10. *Salairocyathus* (*Salairocyathus*) *annulatus* (R. & W. R. Bedford)

possible to distinguish their arrangement. Septa and tabulae frame somewhat parallelepipedic loculi. The rectangular openings of the inner wall are bounded by the inner edges of the septa and a vertical series of horizontal bars, which are annular in form. The β component of the latter is thick and horizontal, while the α component is much thinner and curves backwards up to the middle of the following horizontal row of openings, which are thus partly closed, (see Text-fig. 10).

DIMENSIONS

	(mm.)
Cup:	
Height	27
Diameter	11
Intervallum	?
Interseptum	0·22–0·30
Intertabulum	about 1·35
Outer wall:	
No. of rows of pores per interseptum	probably 4
Thickness	0·13
Inner wall:	
No. of rows of pores per interseptum	1
Diameter of pores (lengthened horizontally)	0·25–0·15
Skeletal partitions (constant thickness)	0·06
Septum:	
Diameter of pores	0·06
Skeletal partitions	0·13
Thickness	0·13
Tabulae:	
Diameter of pores (radially lengthened)	0·13–0·06
Skeletal partitions	0·06
Thickness	0·15

DISCUSSION. This annular form of inner wall was previously unknown. The specimen is described as *Salairocyathus* with reservation.

Family **ALATAUCYATHIDAE** Zhuravleva, 1955

DIAGNOSIS. Cups with simply porous septa and tabulae. Inner wall with simple, or S-shaped pores. Two sub-families are distinguished by the shape of the pores in the outer wall.

Subfamily **TUMULOCOSCININAE** Zhuravleva, 1960

DIAGNOSIS. Outer wall with simple tumuli.

COMPOSITION OF THE SUBFAMILY. *Tumulocoscinus* Zhuravleva 1960, *Ethmocoscinus* Simon 1939, *Asterotumulus* Rozanov 1964.

Subfamily **ALATAUCYATHINAE** Zhuravleva, 1960

DIAGNOSIS. Outer wall with knobbly tumular pores.

COMPOSITION OF THE SUBFAMILY. *Alataucyathus* (*Alataucyathus*) Zhuravleva 1955, *Alataucyathus* (*Anaptyctocyathus*) subgen. nov.

Subfamily **TUMULICOSCININAE** Zhuravleva, 1960

Genus ***ETHMOCOSCINUS*** Simon 1939

1939 *Ethmocoscinus* Simon : 28

TYPE SPECIES. *Coscinocyathus papillipora* R. & W. R. Bedford, by original designation (Simon 1939 : 28).

DIAGNOSIS. Cylindro-conical cups. Outer wall with simple tumuli, one per interseptum. Inner wall with a single row of S-shaped pore-tubes per interseptum. Septa have sparse simple pores. Tabulae with polygonal, somewhat irregular pores.

COMPOSITION OF THE GENUS. A single species *E. papillipora* (R. & W. R. Bedford).

Ethmocoscinus papillipora (R. & W. R. Bedford)

(Pl. 3, fig. 3)

1934 *Coscinocyathus papillipora* R. & W. R. Bedford : 18.
1939 *Ethmocoscinus papillipora* (R. & W. R. Bedford) Simon : 28.

HOLOTYPE. B.M. (N.H.) S 4164.

DESCRIPTION. The holotype, the only known specimen, is partly weathered-out and shows the structure of the two walls. The straight septa are perforated by round regular pores, which although few, are arranged in quincunx. A single tabula is visible (it is therefore impossible to state the frequency) and consists of a net of regular pores. The papillae of the outer wall are situated between the septa in vertical rows, which are just separate from one interseptum to the next. The papillae of the inner wall occupy a much larger area and also appear to be in alternate vertical rows.

DIMENSIONS

	(mm.)
Cup:	
Height (pars)	20
Diameter	7·5
Intervallum	1·2
Interseptum	from 0·41–0·45
Number of septa	26
Parietal coefficient	3·4
Intervallum coefficient	0·2
Outer wall:	
No. of pore rows per intersept	1
No. of pore rows before formation of septa	2
Diameter of papilla	0·34–0·22
Thickness of papilla	0·07
Height of papilla	0·18
Horizontal partitions	0·15–0·18
Vertical partitions	0·11
Inner wall:	
No. of rows of pores per interseptum	1
Diameter of pores	0·37
Partitions	0·11
Septa:	
No. of rows of pores per intervallum	4
Diameter of pores	0·11
Partitions	0·11
Thickness	0·06
Tabula:	
No. of rows of pores per interseptum	6
Diameter of pores	0·07
Partitions	0·03
Thickness	0·03

Subfamily **ALATAUCYATHINAE** Zhuravleva, 1960

Genus ***ALATAUCYATHUS*** Zhuravleva, 1955

1955 *Alataucyathus* Zhuravleva : 626, figs. 1a, 2d.

Type Species. By original designation *Alataucyathus jaroschevitschi* Zhuravleva 1955 : 626.

Diagnosis. Intervallum filled with simple septa and tabulae. Outer wall covered with small multi-perforate knobs. Inner wall simple with vertical folds between neighbouring septa.

Discussion. As mentioned in the discussion on *Tomocyathus*, it is considered that species having non-fluted inner walls, should be placed in a separate sub-genus.

Subgenus ***ALATAUCYATHUS*** (***ANAPTYCTOCYATHUS***) nov.

Derivation. *anaptyctos* = unfolded.

Type Species. *Coscinocyathus cribripora* R. & W. R. Bedford designated here.

Composition of the genus. *A.* (*A.*) *cribripora* (R. & W. R. Bedford, 1934), *A.* (*A.*) *minimiporus* (R. & J. Bedford 1937)—included with some doubt as the structure of the walls is not certain, *A.* (*A.*) *excellenthis* (Rozanov 1964), *A.* (*A.*) *verschkhovskajae* (Zhuravleva 1961), and *A.* (*A.*) *flabellus* nov.

Alataucyathus (***Anaptyctocyathus***) ***cribripora*** (R. & W. R. Bedford)

(Pl. 11, figs. 1 and 3)

1934 *Coscinocyathus cribripora* R. & W. R. Bedford : 3, pl. 3, fig. 15.

Holotype. B.M. (N.H.) S 4160.

Description. Cylindrical cup. Intervallum with straight radial septa, in which the hexagonal pores occupy a much larger surface in proportion to the skeletal tissue, and irregularly distributed flat tabulae, that are finely perforated by very narrow pores.

The inner wall is simple, with two rows of pores per interseptum, which are only weakly separated, in fact, towards the upper part of the cup, two neighbouring pores may sometimes coalesce. The pores of the outer wall are covered by knobs, that are perforated by a central pore and a surrounding circle of six others.

Dimensions

	(mm.)
Cup:	
Height (*pars*)	36
Upper diameter	12
Lower diameter	6
Intervallum coefficient	0·28
Interseptum (Upper diameter)	0·74
(Lower diameter)	0·56
Intertabula	2–5

DIMENSIONS—*continued*

	(mm.)
Outer wall:	
No. of rows of main pores per interseptum (each pore covered by a sheath with 7 micropores)	2
Main pore diameter	0·27
skeletal partitions	0·27–0·30
Micropore diameter	0·07
skeletal partitions	0·03
Inner wall:	
No. of pore rows per interseptum	2 (these sometimes coalesce)
Diameter of pores	0·30
Skeletal partitions	0·07
Septa:	
No. of hexagonal pores	4–5
Diameter	0·15–0·18
Vertical partitions	0·18
Horizontal partitions	0·18
Tabulae:	
No. of pores	10–4
Diameter	0·11–0·06
Partitions	0·07

DISCUSSION. *A.* (*A.*) *cribripora* differs from the two Russian species by having lower tumuli, coarse micropores and a thicker inner wall.

Alataucyathus (*Anaptyctocyathus*) *flabellus* nov.

(Pl. 10, fig. 1)

HOLOTYPE. B.M. (N.H.) S 4161.

DESCRIPTION. Bowl-shaped cup with narrow intervallum. Regularly porous septa in alternate vertical rows. The tabulae almost join, their pores are much thinner than those of the septa. The inner wall is only known from the intervallum side and therefore, it is not possible to discover whether there are spines on the central cavity face. Three vertical rows of pores can be distinguished per interseptum. The outer wall has 2–3 pores, each covered by a small microporous tumulus with about ten angular pores in each.

DIMENSIONS

	(mm.)
Cup:	
Height (*pars*)	20
Span of visible arc	78
Intervallum	2
Loculi	1/2/3
Outer wall:	
No. of rows of pores per interseptum	from 2–3
Diameter of main pores	0·40–0·27

DIMENSIONS—*continued*

	(mm.)
Vertical skeletal partition	0·16
Horizontal skeletal partition	0·11
Diameter of micropores	0·06
Skeletal partition between micropores	0·03
Inner wall:	
Diameter of pores	0·18
Skeletal partitions	0·22
Thickness	**0·20**
Septa:	
Diameter of pores	0·20
Vertical partitions	0·30
Horizontal partitions	0·20
Thickness	0·11
Tabulae:	
No. of rows of pores per interseptum	5
Diameter of pores	0·06
Skeletal partitions	0·06
Thickness	0·11

DISCUSSION. Differs from *A.* (*A.*) *cribripora* by its bowl-shaped cup, the specific coefficients and the different arrangement of the outer wall pores.

Class *IRREGULARIA* Vologdin, 1937

Order ARCHAEOCYATHA Okulitch, 1935

Family **DICTYOCYATHIDAE** Taylor, 1910

DIAGNOSIS. Cups with intervallum containing disorientated short rods and dissepiments. Two simply porous walls.

COMPOSITION OF THE FAMILY. *Dictyocyathus* Bornemann 1891, *Spinosocyathus* Zhuravleva 1960, *Pinacocyathus* R. & W. R. Bedford 1934, *Agastrocyathus* Debrenne 1964, *Archaeopharetra* R. & W. R. Bedford 1936, *Chouberticyathus* Debrenne 1964.

Genus ***PINACOCYATHUS*** R. & W. R. Bedford, 1934

1934 *Pinacocyathus* R. & W. R. Bedford : 4, fig. 21.
1964 *Pinacocyathus* R. & W. R. Bedford; Debrenne : 200
1965 *Pinacocyathus* R. & W. R. Bedford; Hill : 117, fig. 22, 7a and b.

TYPE SPECIES. By monotypy *Pinacocyathus spicularis* R. & W. R. Bedford 1934 : 4.

DIAGNOSIS. Two-walled cup with intervallar rods. The outer wall is formed by a scaffolding of vertical pillars connected by horizontal, or slightly oblique rods. The inner wall is, probably, a regular net. Oblique, or radial horizontal rods in the intervallum.

COMPOSITION OF THE GENUS. A single species; *P. spicularis*.

Pinacocyathus spicularis R. & W. R. Bedford

(Pl. 12, figs. 1, 2, Text-fig. 11)

1934 *Pinacocyathus spicularis* R. & W. R. Bedford : 4, fig. 21.

Holotype. By monotypy B.M. (N.H.) S 4169.

Description. Conical tube. The outer wall consists of an open framework, which is mainly composed of vertical columns arranged around the cup at almost regular intervals. This framework is completed by horizontal, or oblique rods,

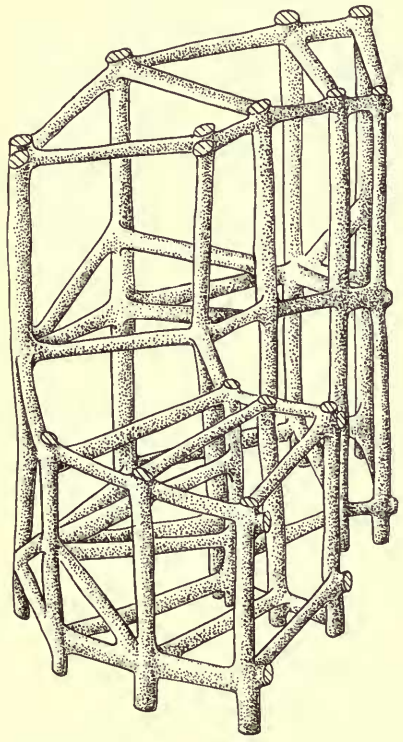

Fig. 11. *Pinacocyathus spicularis* R. & W. R. Bedford

which connect the columns, with a few spines occurring at the junctions. On the lower part, the net is more compact but hidden by poor preservation, that has swollen the structures. Only one vertical row of the inner wall can be seen and this seems to be composed of a regular mesh. However, it was not possible to determine the arrangement of the intervallar rods. They seem to arise from the skeletal junctions of the outer wall framework and continue radially, or obliquely towards the inner wall. The framework is probably thicker in its lower parts.

DIMENSIONS

	(mm.)
Cup:	
Height (*pars*)	15
Diameter	5·75
Intervallum	1·42
Central cavity	0·6
Outer wall:	
Diameter of pores	0·55
Distance between vertical rods	0·67–1·0
Distance between horizontal rods	1·35–1·70
Thickness of vertical rods	0·33
Thickness of horizontal rods	0·33
Thickness of oblique rods	0·25
Inner wall:	
Diameter of pores	0·33
Vertical partitions	0·20
Horizontal partitions	0·20
Thickness	0·20
Intervallar rods:	
Thickness	0·27

DISCUSSION. Only one specimen of this curious form is known. It is included in the Dictyocyathidae because of its scaffolding of intervallar rods, but no other recognized genus has such a loosely-spaced framework.

Family **FLINDERSICYATHIDAE** R. & J. Bedford, 1939

DIAGNOSIS. Two-walled cups, simply porous, with a single series of large pores in the inner wall. A scaffolding of rods fills the intervallum, consisting of taeniae, that cross the intervallum, joining the septa, and undulate in a radial plane, together with synapticulae, which connect the crests of neighbouring taeniae. Little to no vesicular tissue is present. Apex of *Dictyocyathus*-type.

COMPOSITION OF THE FAMILY. *Spirocyathella* Vologdin 1939, *Flindersicyathus* (*Flindersicyathus*) R. & J. Bedford 1937, *Flindersicyathus* (*Pycnoidocyathus*) (Taylor 1910), ? *Spirillicyathus* R. & J. Bedford, 1937, *Copleicyathus* R. & J. Bedford 1937.

Genus ***FLINDERSICYATHUS*** R. & J. Bedford, 1937

1910 *Pycnoidocyathus* Taylor : 131.
1937 *Flindersicyathus* R. & J. Bedford : 28.
1939 *Flindersicyathus* R. & J. Bedford; Simon : 30.
1960 *Archaeocyathus* Billings; Zhuravleva : 296 (*pars*).
1965 *Flindersicyathus* R. & J. Bedford; Hill : 123.

TYPE SPECIES. *Flindersicyathus decipiens* R. & J. Bedford, by subsequent designation R. & J. Bedford (1939(May) : 78), which has priority over *Spirocyathus irregularis* Taylor chosen by Simon (1939 (Dec.) : 30), see Hill (1965 : 123). Holotype material No. 86670 in Princeton University, U.S.A.

DIAGNOSIS. Hill (1965 : 123) writes: " solitary cups, with simply porous outer wall; inner wall with a single series of large rounded pores per intertaenial loculus,

each pore bounded by the taeniae and the synapticulae joining them, and each with a louvre-like plate projecting upwards and inwards to the central cavity from its low synapticula". [In fact, each pore is a short tube with the lower part projecting into the central cavity, rather than a simple pore with a projecting plate.] Intervallum with taeniae, sparsely porous near the inner wall, coarsely and copiously porous elsewhere; the taeniae are waved in the radial plane, and the waves have angulated crests and troughs, the crests and the trough-lines curving upwards and outwards

FIG. 12. *Archaeocyathus atlanticus* Billings × 4

from the inner wall; the crests of neighbouring taeniae are opposed and connected by synapticulae. Rare dissepiments may occur. No tabulae".

DISCUSSION. R. & J. Bedford (1937 : 28) and Hill (1965 : 123 and 128) point out that *Flindersicyathus* R. & J. Bedford and *Pycnoidocyathus* Taylor have a very similar structure. The latter differs only in having much stronger transverse annulations of the intervallum, the inner wall of both remaining cylindrical. The two genera may be synonymous, but I have not seen examples of the type species of *Flindersicyathus*, or the type material of *Pycnoidocyathus* and therefore cannot settle the question. My tentative suggestion is that *Pycnoidocyathus* should be considered a subgenus of *Flindersicyathus*, due to its different outer shape, although possibly having a similar structure. This situation is comparable to the distinction between *Ajacicyathus* R. &

J. Bedford and *Orbicyathus* Vologdin, which are considered to be subgenera distinguished by their external shape.

Zhuravleva (1960 : 296) placed *Flindersicyathus* in synonymy with *Archaeocyathus* Billings 1861. Debrenne (1964 : 117) doubtfully placed *Flindersicyathus* in the family Archaeocyathidae (as did Hill 1965 : 123), but had maintained its independence. However, having seen the holotype of *Archaeocyathus atlanticus* Billings (1861, fig. 10). I can state that the taeniae are thickened by several skeletal layers, have few and irregular pores (Text-fig. 12), are goffered longitudinally and transversely, and are occasionally connected to the opposite crests, more or less forming elongated pores. The curved hexagonal tubular mesh of *Flindersicyathus* was not recognized. Further characters which separate the two genera are the abundant vesicular tissue, the pore canals of the inner wall and the irregular net of the outer wall of *Archaeocyathus*.

Composition of the Genus. *Flindersicyathus* (*Flindersicyathus*): *F. decipiens* R. & J. Bedford, 1937, *F. circliporus* R. & J. Bedford, 1937, *F. contractus* Hill 1965, *F. graphicus* (R. & W. R. Bedford 1934), *F. irregularis* (Taylor 1910), *F. latiloculatus* Hill 1965, *F. major* (R. & W. R. Bedford 1934), *F. multifidus* (R. & W. R. Bedford 1936), ? *F. macdonnelli* R. & J. Bedford 1937, *F. rete* (R. & W. R. Bedford 1936), *F. simplex* (Taylor 1910), *F. speciosus* (R. & W. R. Bedford 1934), *F. tabulatus* R. & J. Bedford 1937.

Flindersicyathus (*Pycnoidocyathus*): *F. synapticulosus* (Taylor 1910), *F. maximipora* (R. & W. R. Bedford 1936), *F. parvulus* (R. & W. R. Bedford 1936), *F. ptychophragma* (Taylor 1910), *F. vicinisepta* (R. & W. R. Bedford 1936).

Flindersicyathus (*Flindersicyathus*) *graphicus* (R. & W. R. Bedford)

(Pl. 12, figs. 3–5, Text-fig. 13)

1934 *Protopharetra graphica* R. & W. R. Bedford : 4, pl. 4, fig. 22.
1939 *Dictyocyathus graphicus* (R. & W. R. Bedford) R. & J. Bedford : 73.
1964 *Metaldetes graphica* (R. & W. R. Bedford) Debrenne : 220.

Holotype. B.M. (N.H.). S 4170.

Paratypes. B.M. (N.H.) S 4171–4173.

Other Material. B.M. (N.H.) S 4761, S 7629.

Description. Slender conical cups, undulating exterior form, with the bulges of the inner wall following those of the outer wall, so that the intervallum remains a constant width. Thin outer wall, perforated by hexagonal to ellipsoidal pores, recalling the outer wall of the Regularia. There is no specific inner wall, but, instead, the innermost face is formed by the inner edges of the taeniae and connecting bars, which enclose apertures that are, in effect, " wall pores ".

The structure of the intervallum can, perhaps be considered as an assemblage of septa of the *Volvacyathus*-type, with regular, somewhat rounded, hexagonal pores set in a radial plane, with the line of pores curving upwards and outwards from the inner to the outer wall. These pseudo-septa (flat taeniae) are joined to one another by horizontal synapticulae and join the skeleton at each pore angle. No vesicular tissue. Early stages of the species unknown.

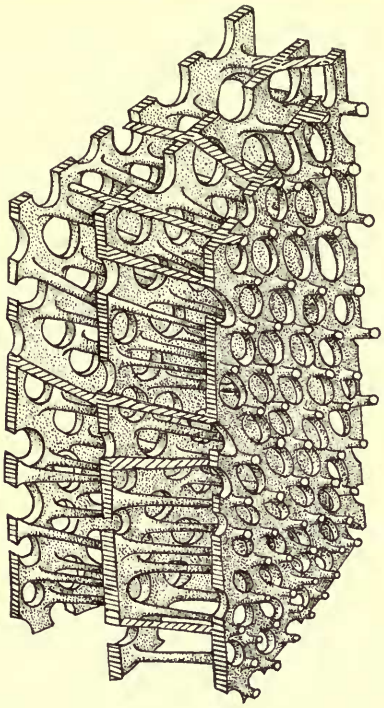

FIG. 13. *Flindersicyathus* (*Flindersicyathus*) *graphicus* (R. & W. R. Bedford)

DIMENSIONS

	S 4170 (mm.)	S 4171 (mm.)	S 4172 (mm.)	S 4173 sup. (mm.)	S 4173 inf. (mm.)	S 7629 (mm.)	S 4761 (mm.)
Cup:							
Height	35	45	15	..	..	45	30
Diameter	12	14	15	7	4	20	18
Intervallum	1·9	1·7	2	1·5	1·13	1·5	1·5
Intervallum coefficient	0·25	0·17	0·18	0·3	0·6	0·1	0·1
Bars:							
Radial distance	0·26	0·18	0·34	0·15	0·15	0·37	0·22
Tangential distance	0·26	0·26	0·41	0·22	0·30	0·30	0·22
Vertical distance	0·37	0·26	0·37	..	..	0·36	0·22
Thickness	0·07	0·07	0·07	0·07	0·07	0·07	0·07
Outer wall:							
No. of pores per intertaeniae	3	3	..	..	..	3	3
Diameter of pores	0·11–0·09	0·07	..	..	..	0·11	0·11
Partitions	0·03	0·03	..	..	..	0·05	0·07
Thickness	0·11	0·07	0·11	0·05	..	0·07	0·07
Inner wall:							
No. of pores per intertaeniae	1	1	..	1	..	..	..
Diameter of pores	0·26	0·22	0·37	0·18	..	0·18	0·18
Partitions	0·13	0·07	0·15	0·07	..	0·11	0·11
Thickness	0·18	0·11	..	0·11	0·07	..	..

Discussion. The taeniae (pseudosepta) of *graphicus* are not waved in the radial plane, as has been described in *F. decipiens* (R. & J. Bedford) probably because of the narrowness of the intervallum and the density of the taeniae and synapticulae. The inner wall does not have a plate on the lower part of the pore. Thus *graphicus* is much simpler than other species of *Flindersicyathus*, but the presence of well defined radial plates (flat taeniae) indicates a more complex stage than that of having sparse rods or plaquettes.

The species was first described as *Protopharetra*, subsequently as *Dictyocyathus* and then, in 1964, removed to *Metaldetes* because of the pseudosepta. However, it differs from *Metaldetes* in having a very regular outer wall, numerous synapticulae and the absence of connections between these. The scaffolding of the intervallar mesh is very like that of *Tabellaecyathus* Fonin but the walls are simpler, neither tabello-reticulate nor tabello-porous.

Flindersicyathus (*Flindersicyathus*) *irregularis* (Taylor)

(Pl. 14, fig. 4)

1910 *Spirocyathus irregularis* Taylor : 148, pl. 16, figs. 93–94.
1936 *Spirocyathus irregularis* Taylor; R. & W. R. Bedford : 14, pl. 13, fig. 64.
1937 *Flindersicyathus irregularis* (Taylor) R. & J. Bedford : 28.
1937 *Spirocyathus atlanticus* Billings; Ting : 368–369, pl. 13, fig. 14.
1961 *Archaeocyathus irregularis* (Taylor) F. & M. Debrenne : 702, pl. 20, fig. 5.

Material. B.M. (N.H.) S 7625, S 4763.

Description. Two-walled cup with numerous thin radial taeniae, probably quite porous [a deduction made from Taylor's comparison with *F. rete* in his original description of *F. irregularis* and not from observation, as no specimen showing a longitudinal section was available], wavy and connected by synapticulae which form a network of more or less regular polygonal apertures, particularly in the outer part. Vesicular tissue sparse. Skeletal tissue is sometimes thickened by secondary layers and occurs mainly near the inner wall (see Pl. 14, fig. 4; also F. & M. Debrenne, 1961, pl. 20, fig. 5). Thin outer wall, with numerous small pores; inner wall with one vertical row of pores per intertaenial space.

Dimensions

	Taylor (mm.)	Ting (mm.)	S 7625 (mm.)	S 4763 (mm.)
Cup:				
Height (*pars*)	50	17	16	25
Diameter	14	16·5	18	20
Intervallum coefficient	0·5	0·8	0·8	0·9
Intertaenial space	0·5	0·4	0·45	0·5
Intersynapticular space				
Horizontal	..	..	0·70	0·6
Vertical	..	..	irregular	..
Taeniae thickness	0·1	0·12	0·2	0·2

DIMENSIONS—*continued*

	Taylor (mm.)	Ting (mm.)	S 7625 (mm.)	S 4763 (mm.)
Outer wall:				
Diameter of pores	..	0·2–0·4	..	..
Partitions	..	0·12	..	..
Thickness	..	0·12	0·13	0·15
Inner wall:				
Diameter of pores	..	0·5	0·35	0·33
Partitions	..	0·3	0·27	0·3
Thickness	..	1	1	1

DISCUSSION. The taeniae are thinner and more numerous than in other species of *Flindersicyathus*, and the thickening of the inner wall recalls some transverse sections of *Copleicyathus confertus* R. & J. Bedford (Hill 1965: pl. 10, figs. 4a–b), but at the moment, it is not possible to take the comparison any further.

Flindersicyathus* (*Flindersicyathus*) *major (R. & W. R. Bedford)

(Pl. 14, fig. 2)

1934 *Spirocyathus major* R. & W. R. Bedford : 5, pl. 4, fig. 24.

HOLOTYPE. B.M. (N.H.) S 4174.

DESCRIPTION. Only one broken specimen known. The outer wall is obscured by silicification. The inner wall has round, shaft-like pore tubes, that are limited by neighbouring taeniae and successive vertical synapticulae; the lower part of each tube is inclined downwards into the intervallum and projects slightly into the central cavity, whereas the upper part is flattened. The rows of pore-tubes alternate. The pores are more crowded at the base of the cup, because the taeniae are closer together there.

The intervallum is crossed by waved taeniae, with the crests and troughs of neighbouring taeniae opposite to one another. Abundant synapticulae join the taeniae, particularly in the central and outer parts of the intervallum. The ratio diameter of taenial pores: distance apart of the synapticulae is close to unity, so that the intervallum has the appearance of a tubular mesh with tubes curving upwards and outwards.

DIMENSIONS

	(mm.)
Cup:	
Height (*pars*)	40
Diameter	about 20
Intervallum	10
Interseptum	1·5
Outer wall:	
Thickness	0·20
Inner wall:	
Diameter of pores : horizontal	1·70
vertical	1·15
Horizontal partitions	1·15
Lateral partitions	0·33
Tubes:	
Irregular diameter	about 0·67
Large skeletal plates	
Thickness	0·27

Discussion. The septa are at wider intervals than in other species of *Flindersicyathus*.

Flindersicyathus (*Flindersicyathus*) *speciosus* (R. & W. R. Bedford)

(Pl. 14, figs. 1, 3)

1934 *Spirocyathus speciosus* R. & W. R. Bedford : 5, pl. 4, fig. 25.

Holotype. B.M. (N.H.) S 4175.

Description. Only a single broken specimen known. The taeniae are thin, radial, slightly waved and connected by sparse synapticulae, which are chiefly found in the outer part of the cup. The diameter of the taenial pores is less than the width of the skeletal tissue between them.

Outer wall with 4 to 5 alternating vertical rows of round pores per interseptum. The inner wall has a single tube per intertaenial space, the lower part of which projects into the central cavity, giving the tube a crescentic section. The rows alternate.

Dimensions

	(mm.)
Cup:	
Height (*pars*)	30
Upper diameter	about 13·5
Lower diameter	11
Intervallum	4·5
Intervallum coefficient	1
Intertaenial space; lower end of cup	0·6
upper part of cup	0·75
Outer wall:	
Diameter of pores	0·15
Vertical skeletal partitions	0·07
Horizontal skeletal partitions	0·18
Inner wall:	
Diameter of pores; horizontal	0·9
vertical	0·4
Vertical skeletal partitions	0·13
Crescentic plates	0·33

Discussion. The taeniae are less waved and not so distinct as those in *Flindersicyathus major*. The shaft-like tubes of the latter are not present, while the inner wall pores of *speciosus* are crescentic and very close together. Synapticulae are less numerous than in other *Flindersicyathus* species.

Subgenus *FLINDERSICYATHUS* (*PYCNOIDOCYATHUS*) (Taylor), 1910

1910 *Pycnoidocyathus* Taylor : 132.
1939 *Pycnoidocyathus* Taylor; R. & J. Bedford : 78.
1965 *Pycnoidocyathus* Taylor; Hill : 128

Type Species. *P. synapticulosus* Taylor (1910 : 132) by subsequent designation R. & J. Bedford, (1939 : 78); type material in the Univ. of Adelaide.

Discussion. Although Hill (1965 : 128) has provisionally treated this as a genus separate from *Flindersicyathus*, I regard it as a subgenus (see p. 345). It is very like *Flindersicyathus*, but with much stronger expansions and contractions of the inter-

vallum which do not affect the inner wall. The problem can only be settled by examination of the type material, in order to discover whether dissepiments occur and the exact nature of the inner wall pores.

Flindersicyathus (*Pycnoidocyathus*) *synapticulosus* (Taylor)

(Pl. 15, fig. 1)

1910 *Pycnoidocyathus synpaticulosus* Taylor : 132, pl. 12, fig. 69.
1936 *Pycnoidocyathus synapticulosus* Taylor; R. & W. R. Bedford : 15, pl. 15, fig. 69.

HOLOTYPE. Probably at Adelaide University.

MATERIAL. B.M. (N.H.) S 208, S 4825.

DESCRIPTION. Large cup with annular bulges. On the specimens examined here, the outer part of each bulge is made of successive flanges. Outer wall with somewhat irregular polygonal fine pores. Inner wall with a vertical series of short tubes per intertaenial space, the tubes lead upwards into the central cavity. Taeniae are radial, nearly flat and close together, particularly near the synapticulae, so that transverse sections appear to be composed of irregular polygonal cells. Abundant horizontal and vertical synapticulae; generally arranged in quincunx from one interseptum to the next. It was not possible, to examine the size and arrangement of pores in tangential section, but Taylor's description (1910 : 132) and Bedford's figure (1936, fig. 69) confirm my observations from transverse sections which suggest the pores are small, isolated and without any important modifications in the lateral bulges. No vesicular tissue.

DIMENSIONS

	(mm.)
Cup:	
Diameter	about 85
Intervallum	
without bulges	8
largest part	19
Interseptum	1·07
Synapticulae	
horizontal	1–2
vertical	0·6–2
Outer wall:	
No. of pores per interseptum	4
Diameter of pores	0·13
Partitions	0·06
Inner wall:	
No. of pores per interseptum	1
Diameter of pores	0·33
Horizontal partitions	0·67
Thickness	0·67
Taeniae:	
Thickness	0·1

DISCUSSION. This is the largest species of *Flindersicyathus* (*Pycnoidocyathus*) known. It has regular annular bulges, the skeletal tissue of the wavy taeniae occupies a greater area than the pores, and the synapticulae are more numerous than in any other species of this genus.

Flindersicyathus (*Pycnoidocyathus*) *simplex* (Taylor)

(Pl. 15, fig. 2)

1910 *Pycnoidocyathus simplex* Taylor : 134, pl. 2, fig. 7c.
1936 *Pycnoidocyathus simplex* Taylor; R. & W. R. Bedford : 15, pl. 15, fig. 70.

HOLOTYPE. Probably in the South Australian Museum.

MATERIAL. B.M. (N.H.) S 4824.

DESCRIPTION. Broken piece showing well-preserved inner wall. Taeniae are radial, not waved and are joined with the synapticulae, chiefly towards the exterior. Outer wall is only see on part of a transverse section, where a small weathered-out surface shows that the pores are arranged in irregular quincunx. Inner wall has a vertical row of pores per intersept, each pore having a raised lower edge and is vertically elongated but flattens towards the top. The rows of pores alternate in quincunx.

DIMENSIONS

	(mm.)
Cup:	
Height (*pars*)	40
Diameter	about 22
Intervallum	5·5
Central cavity	13
Intervallum coefficient	0·4
Intertaenial space	1
Outer wall:	
Diameter of pores	0·40–0·33 (hor.)
Skeletal partitions	0·20–0·20
Thickness	0·13
Inner wall:	
Diameter of pores	1·69–1·42 (hor.)
Vertical partitions	0·20
Horizontal partitions	0·47
Taeniae:	
Diameter of pores	0·6
Vertical partitions	0·13
Horizontal partitions	0·20
Thickness	0·1

DISCUSSION. The measurements of the specimen described above correspond to those given by Taylor (1910). R. & W. R. Bedford (1936 : 15, fig. 70) pointed out and sketched the regular annular bulges from an example of the same species. *F.* (*P.*) *simplex* differs from typical *Pycnoidocyathus* by the scarcity of its synapticulae and the straight taeniae.

Flindersicyathus (*Pycnoidocyathus*) *maximipora* (R. & W. R. Bedford)

(Pl. 15, fig. 3)

1934 *Pycnoidocyathus maximipora* R. & W. R. Bedford : 3, pl. 2, figs. 9a–c.
1936 *Pycnoidocyathus maximipora* R. & W. R. Bedford : 15, pl. 15, fig. 71.

HOLOTYPE. B.M. (N.H.) S 4150.

DESCRIPTION. One broken specimen with a single annulate bulge. Intervallum crossed by un-waved radial, porous taeniae, with the skeletal tissue forming a greater area than the pores, and sparse synapticulae, that occur mainly in the lower part of the fragment. The taenial pores, are round and arranged in lines, which curve upwards and outwards, near the inner wall; but are oval and bigger near the outer wall and inside the annular bulge. The thin, irregular, outer wall is strengthened by bars springing from the taeniae, but both partial weathering and preservation give an irregular and false idea of its original structure.

The inner wall is composed of very short piled-up pipes, leading obliquely upward, with one row per intertaenial space, which alternates with the next. The cross-section of the pipe is vertically oval. Each pipe is withdrawn from the one immediately above and its sides are stretched slightly to join with its neighbours. Thus, the inner wall does not present a flat surface to the central cavity but has the appearance of a rasp. The various sections have suggested to previous authors that there is a louvre-like plate at the lower part of each pore, but, in fact, these are the short pipes.

DIMENSIONS

	(mm.)
Cup:	
Height (*pars*)	35
Diameter	22
Intervallum	6
Intertaenial space	1·3
Outer wall:	
Diameter of the pores	0·4
Partitions	0·3
Thickness	0·4
Inner wall:	
Diameter of the pores	1·49–2·71
Lateral partitions	0·13
Horizontal partitions	2·03
Taeniae:	
Diameter of the pores near the inner wall	0·6
near the outer wall	0·8–2·35
Partitions	0·27–0·40

DISCUSSION. This species differs from others by the greater development of tubes in the inner wall and its relatively narrower taenial pores.

Flindersicyathus (*Pycnoidocyathus*) *vicinisepta* (R. & W. R. Bedford)

(Pl. 15, fig. 4)

1936 *Pycnoidocyathus vicinisepta* R. & W. R. Bedford : 15, pl. 16, fig. 72.

HOLOTYPE. Probably in the South Australian Museum.

MATERIAL. B.M. (N.H.) S 4825.

DESCRIPTION. A longitudinally cut fragment. Several annulate horizontal bulges are visible, they are rather narrow and close together. Radial un-waved taeniae

joined by numerous synapticulae. In the bulges, the taeniae are waved with opposite crests connected by synapticulae, so that the intervallum has the aspect of a polygonal mesh. A very small part of the outer wall is preserved in which the pores are irregular and polygonal. The inner wall has one vertical row of pore-tubes leading up into the central cavity, in each intertaenial space. The rows alternate.

DIMENSIONS

	(mm.)
Cup:	
Height (*pars*—in two pieces)	95
Diameter	22
Bulge	4
Intervallum without bulge	4
Central cavity	14
Intertaenial space	0·33
Intersynapticular space	0·47–0·67
Outer wall:	
Diameter of pores	0·06
Skeletal tissue	0·05
Thickness	not known
Inner wall:	
No. of rows of pores per intertaenial space	1
Horizontal partitions	0·27
Vertical partitions	0·40
Diameter of pores	0·40
Thickness	0·40
Taeniae:	
Diameter of pores	0·27
Horizontal partitions	0·81
Vertical partitions	0·67
Thickness	0·10

DISCUSSION. As far as I can tell, after measuring the drawings of Bedford, the coefficients correspond to those of *vicinisepta*. This species differs from other *Pycnoidocyathus* in having many more taeniae.

Family **METACYATHIDAE** R. & W. R. Bedford, 1934

DIAGNOSIS. Cups growing from an apex without central cavity, occupied by rods, plates and dissepiments. Adult stages with more or less definite radial septa, the pores of which are arranged in rows inclined upwards and outwards from inner to outer wall. Dissepiments and sometimes synapticulae present. Simple porous outer and inner walls, with the pores sometimes screened by a microporous sheath or pellis.

COMPOSITION OF THE FAMILY. *Protopharetra* Bornemann 1887, *Volvacyathus* Debrenne 1961, *Dendrocyathus* Okulitch & Roots 1947, ? *Shidertycyathus* Krasnopeeva 1959, *Metaldetes* Taylor 1910, *Cambrocyathus* Okulitch 1937, *Cambrocyathellus* Zhuravleva 1960, *Okulitchicyathus* Zhuravleva 1960, *Paranacyathus* R. & J. Bedford 1937, ? *Ardrossacyathus* R. & J. Bedford 1937, *Metafungia* R. & W. R. Bedford 1934.

Genus *METALDETES* Taylor, 1910

1910 *Metaldetes* Taylor : 151, pl. 15, figs. 86–88, t.-figs. 11, 37 and 38.
1934 *Metacyathus* R. & W. R. Bedford : 5.
?1957 *Bedfordcyathus* Vologdin : 182 and 209.

Type Species. By monotypy *Metaldetes cylindricus* Taylor 1910, the holotype of which is in the University of Adelaide.

Diagnosis. Solitary, or sometimes colonial cups; the central cavity and the inner wall slowly develop later. In the lower part of the cup, the irregularly arranged skeletal structures (bars, rods, plates and vesicular tissue) fill the whole inner space. Much later, the central cavity is defined by the formation of a regularly porous inner wall and the structures of the intervallum are arranged in radial plates; the tangential links (synapticulae and dissepiments) may continue into the adult stage.

Unfortunately, the type specimen of the genus has not been re-described yet and one has to rely on the original account and illustrations. According to Taylor (1910 : 151), the rugose character of the outer wall causes a transverse section to resemble a series of tridents. R. & W. R. Bedford (1934 : 5) considered the outer wall to be a double porous sheath, and my own observations agree with this (Debrenne 1964 : 219). Hill (1965 : 119) mentions that the longitudinal ribs between the rows of pores are connected together, some distance behind the outer edge, by transverse bars. The inner wall, which is absent in the lower part of the cup, was described by Taylor (1910 : 152) as being " strongly ridged on its septal side ". These ridges correspond to the beginnings of the taeniae, which are slightly thickened towards the inner wall. The number of pores per intersept is not certain (1, 2, or 3), nor their shape and size.

Discussion. A complete revision of the type material is desirable, but although *Metaldetes* is incompletely known, it is possible to regard two subsequent genera, *Metacyathus* Bedford and *Bedfordcyathus* Vologdin, both found at the same locality and level, as synonyms. Okulitch (1955 : E 16), Zhuravleva (1960 : 283) and myself (Debrenne 1964 : 220) have previously considered *Metacyathus* a synonym of *Metaldetes*, but Vologdin (1957 : 43) and Hill (1965 : 118) thought it to be a separate genus. R. & W. R. Bedford established the genus to include those species in which the taeniae occur as straight radial septa in the inner two-thirds of the intervallum, but are separate from the outer wall, as in the type *M. taylori* R. & W. R. Bedford

Examination of the holotype of *M. taylori* shows that the structures of the intervallum are disturbed by the occurrence of exothecal lamellae, but that, at other levels, the plates continue from one wall to the other. The porosity of the outer wall depends on the presence or absence of the exotheca; the inner wall has one vertical row of pores per intertaenial space in the lower part of the cup, but two or more in the upper part, with probably a second wall.

Bedfordcyathus was established by Vologdin, after he had studied Bedford's figures, to group into a separate genus those species that have a strong development of vesicular tissue. The holotype of the type species (*M. irregularis* Bedford), now in the British Museum (Natural History), is described below. It shows that there is no

appreciable difference from *Metacyathus*, in the structure of the intervallum (apart from the abundance of vesicular tissue), or in that of the walls. I think that vesicular tissue is too inconstant and variable a character to be sufficient grounds for establishing a new genus.

The genus *Metaldetes* is therefore defined as consisting of cups which grow from a base that does not have a distinct central cavity, where the skeletal elements have not attained a clear radial arrangement, and where tangential links (synapticulae and vesicular tissue) are numerous. Subsequently, the central cavity is differentiated by a more definite development of the inner wall, which is, at first, part of the intervallum (with one pore per intertaenial space), but then becomes a more distinct structure (with two pores per intertaenial space) and is, perhaps, protected on its central cavity side by a microporous sheath or vesicular membrane. At this same level, the intervallar elements generally form strong, compact, radial taeniae with high oval pores the diameter of which increases along upwardly curving lines from the inner to the outer wall; the largest pores being close to the outer wall. It is in this region that positional changes and external influences occur, the septa become less regular and sometimes revert to curved taeniea. The synapticular links may persist but generally disappear in the adult stage, whereas vesicular tissue is still abundant. The outer wall has a basic layer with irregular polygonal pores, overlapped by a second microporous sheath, which disappears when the cup is surrounded by exothecal lamellae. Fossils reach considerable size.

RELATIONSHIPS AND DIFFERENCES

Volvacyathus Debrenne 1961 has two distinct stages, the apex being quite different from the adult. The walls are still connected with the intervallar network, the septa are not clearly defined and their pores are wider than the intervening skeletal tissue. This genus is also close to *Protopharetra* Bornemann 1887.

Cambrocyathus Okulitch 1937 closely resembles *Metaldetes* in having abundant vesicular tissue, but the adult stage is reached more quickly. The central cavity is not free and is filled by thin skeletal rods and vesicular tissue, which persists as a pellis to the top of the cup. These structures are also found as an exotheca. The well-developed taeniae generally have a laminated structure and are perforated by pores, that are almost in horizontal lines. Scarce synapticulae or branching septa, but abundant vesicular tissue, which earlier authors have interpreted as true synapticulae. Reference material on loan from the Geological Survey of Canada and a topotype from the Yale Peabody Museum showed these features (Text-fig 14).

Septa of *Cambrocyathus*-type (see Debrenne 1964 : 88) are the final stage in the process of radial partition. This starts with *Protopharetra*, leads through *Volvacyathus* (see Debrenne 1964, fig. 51) and the first *Metaldetes* (*proteus* and *dissutus*), with their broken septa, to the complete septa of *Metaldetes irregularis* and finally, to the regular septa of *Cambrocyathus*.

Composition of the Genus. *M. cylindricus* Taylor 1910, *M. columbianus* (Okulitch 1943), *M. dissepimentalis* (Taylor 1910), *M. dissutus* Debrenne 1964, *M. irregularis* (R. & W. R. Bedford 1934), *M. ramulosus* R. & J. Bedford 1937, *M. solidus*

FIG. 14. *Cambrocyathus profundus* (Billings) ×4

(Okulitch 1957), *M. spiralis* R. & W. R. Bedford 1936, *M. superbus* R. & W. R. Bedford 1936, *M. taylori* (R. & W. R. Bedford 1934), *M. proteus* (Bornemann 1887).

Metaldetes dissepimentalis (Taylor)

(Pl. 16, figs. 1–3)

1910 *Archaeocyathus dissepimentalis* Taylor : 128, pl. 10, fig. 53.
1934 *Metaldetes conicus* R. & W. R. Bedford : 5, figs 26, 28 and 31.
1936 *Metaldetes conicus* R. & W. R. Bedford : 18, pl. 18, fig. 77.

HOLOTYPE. Possibly at Adelaide University.

MATERIAL. B.M. (N.H.) S 4176–4182.

DESCRIPTION. Large conical cups. In the first stages, the central cavity is not formed and the entire cup is occupied by un-orientated taeniae, which are joined by numerous dissepiments that are arranged as horizontal vesicles. Much later, the cavity develops, the dissepiments become less abundant and the taeniae form regular radial plates. The general aspect recalls that of *Cambrocyathus profundus* Billings.

The outer wall is twofold: a basal wall covered externally by a very thin microporous sheath. The inner wall is also double; the main wall having two rows of large irregular pores per intersept, with the diameter of the pores being much greater than the width of the skeletal tissue between them; with a microporous sheath, similar to that of the outer wall, occurring on the central cavity side. The microporous sheaths are not well known for they are often eroded and no good tangential sections have been seen. Consequently, the arrangement, size and shape of the micropores is not certain, they appear to be similar to those of the secondary wall in *Metafungia*.

DIMENSIONS

	S 4176	S 4178	S 4179 S 4180 low.	S 4180 up. S 4181	S 4182	*dissepimentalis* Taylor
	(mm.)	(mm.)	(mm.)	(mm.)	(mm.)	(mm.)
Cup:						
Height (*pars*)	60	..	..	15	40	
Diameter	24	13	13	21	45	22
Intervallum	6	4	..	6	7·5	6
Interseptum	0·4–0·7	0·5	0·7	0·5	1·35	7
Intervallum coefficient	0·5	0·8	..	0·6	0·25	0·6
Outer wall:						
No. of rows of pores per interseptum	1–3	1–3	2	2	1–3	2
Diameter	0·17	0·33	0·2	0·20	0·25–0·40	0·30
Skeletal partitions	0·30	0·20	0·15	0·15	0·15–0·20	0·20
Micropores: diameter	0·03	..	0·06	0·06	..	..
skeletal partitions	..	..	0·06	0·06	..	..
Thickness	0·20	0·20	..	..	..	..

DIMENSIONS—*continued*

	S 4176	S 4178	S 4179 S 4180 low.	S 4180 up. S 4181	S 4182	*dissepimentalis* Taylor
	(mm.)	(mm.)	(mm.)	(mm.)	(mm.)	(mm.)
Inner wall:						
No. of pore rows per interseptum	2	2	..	1–3	1–2	1–2
Diameter	0·67	0·47	..	0·33	0·33	0·30
Skeletal partitions	0·16	0·16	..	0·10	0·10	0·10
Micropores: diameter	..	..	..	0·03	0·03	0·03
skeletal partitions	..	..	..	0·03	0·03	0·03
Thickness	..	..	..	..	..	..
Septa:						
Diameter	0·40	..	..	..	0·40	0·20
Skeletal partitions	..	..	..	..	0·40–0·60	..
Thickness	0·13	..	..	0·13	0·20	0·20

DISCUSSION. The description and figures given by Taylor for *Archaeocyathus dissepimentalis* correspond with measurements taken from the photographs of *Metaldetes conicus* Bedford. The two species are, therefore, considered to be synonymous and *dissepimentalis*, the older, is the name conserved.

Metaldetes irregularis (R. & W. R. Bedford)

(Pl. 16, fig. 4)

1934 *Metacyathus irregularis* R. & W. R. Bedford : 6, pl. 5, fig. 29.
1957 *Bedfordcyathus irregularis* (Bedford) Vologdin : 43.
1964 *Metacyathus-Bedfordcyathus irregularis* (R. & W. R. Bedford); Debrenne : 220 and 231.
1965 *Bedfordcyathus irregularis* (R. & W. R. Bedford); Hill : 118, fig. 22.9.

It has not been possible to locate the original description by Vologdin of his genus *Bedfordcyathus*. Both Debrenne (1964) and Vologdin (1957, 1962) give the year 1955 for this genus, but, unfortunately, there is no mention of *Bedfordcyathus* in the paper cited under that year, in either bibliography (*Dokl. Akad. Nauk SSSR*, **103**, 1). In subsequent papers, Vologdin gives the year as 1956, but the only paper available for that year merely includes the genus in a list showing the classification of the Archaeocyatha. This paper appeared in a slightly more elaborate form during 1957, in two journals: *Acta paleont sinica*, **5**: 173–222 and *Annls. Cent. Etud. Docum paleont.*, **23** : 33–80 and it is the latter, which is taken as the basis of the date given in this paper and that of Hill (1965). However, it would appear that the paper referred to, is included in the yet unpublished Vol. 3 of " *El sistema Cambrico . . .* ", Int. Geol. Congr. Mexico, 1955, quoted in some references as 1961.

HOLOTYPE. B.M. (N.H.) S 4189, by monotypy.

OTHER MATERIAL. Paratypes B.M. (N.H.) S 4188, S 4190.

DESCRIPTION. Conical cup, with large irregularly-waved intervallum. Double outer wall; first, a thick basal one, pierced by funnel-shaped pores that widen towards

the exterior; this is covered externally by a very thin microporous sheath. The inner wall is not well known, but from a small poorly preserved surface, appears to be covered by an irregular, microporous, thin wall, which screens the simple pores of the intervallum.

The taeniae in the upper part, are straight, radial and completely cross the intervallum. In longitudinal section, the pores appear circular and alternate in regular lines, curving shallowly towards the exterior from the inner to the outer wall. The skeletal tissue and the pores, occupy equal proportions of the total surface area. Considerable development of vesicular tissue, formed of imbricate, horizontally elongated vesicles, that cross several loculi, but do not penetrate into the central cavity.

DIMENSIONS

	(mm.)
Cup:	
Height (*pars*)	92
Diameter	about 35
Intervallum	10
Intervallum coefficient	0·6
Interseptum	1·35
Outer wall:	
No. of rows of pores per interseptum	2
Diameter of pores	0·27
Partitions	0·20–0·40
Micropores	0·10
Inner wall:	
Diameter of pores	0·35–0·67
Partitions	0·13
Micropores	4 to each main pore
Diameter of micropores	0·05
Thickness	0·06
Taeniae:	
Diameter of pores	0·33–0·54
Partitions	0·27–0·33

DISCUSSION. The strong development of vesicular tissue and the absence of exothecal lamellae, are the main differences between this species and others in the genus.

Metaldetes taylori (R. & W. R. Bedford)

(Pl. 13, figs. 1–3)

1934 *Metacyathus taylori* R. & W. R. Bedford : 5, pl. 5, fig. 10.
1936 *Metacyathus taylori* R. & W. R. Bedford; R. & W. R. Bedford : 18, pl. 18, fig. 80.
1964 *Metaldetes taylori* (R. & W. R. Bedford) Debrenne : 220.
1965 *Metacyathus taylori* R. & W. R. Bedford; Hill : 118, pl. 9, figs. 2a–d.

HOLOTYPE. By monotypy, B.M. (N.H.) S 4185–4187 (three pieces of the same specimen).

DESCRIPTION. Although the three pieces are said to come from the same cup, it is no longer possible to prove this with any certainty, for having been subjected to various palaeontological techniques (cutting, etching etc.), they do not fit together.

Nevertheless, there is little chance of the lower part belonging to another specimen. This is pointed out because the lower part has some structures obviously different from the other two pieces and these are important for generic determination.

The lower part is conical; radial, slightly porous taeniae are connected by synapticulae, which develop between the pores. The inner wall has a single row of pores per interseptum. The outer wall is well defined and separates the intervallum from the exothecal lamellae. Dissepiments present.

In the middle and upper parts of the cup, the inner wall has two rows of pores per interseptum; the outer wall is not yet separate from the exothecal structures, which disturb the outer part of the intervallum and give the septa the form of curved taeniae. No synapticulae, but dissepiments persist. The pseudo-septa are mainly radial at the inner and middle parts of the intervallum, but are interrupted towards the outer wall and disappear near the exothecal lamellae.

DIMENSIONS

	S 4185 Apex (mm.)	S 4186 (mm.)	S 4187 (mm.)
Cup:			
Height (*pars*)	35	55	40
Diameter	16	35 upper	35
		24 lower	
Intervallum	4	11 upper	10
		7 lower	
Intervallum coefficient	0·72	0·8 upper	1
		0·7 lower	
Interseptum	0·33	1	1
Outer wall:			
Thickness	0·06	disappeared	disappeared
Inner wall:			
No. of pore rows per interseptum	1	2	2
Diameter	..	0·33	0·33
Skeletal partitions	..	0·20	0·20
Thickness	..	?	?
Taeniae	..	0·40–0·60	0·60
Diameter of pores	..	0·40	0·40
Thickness	..	0·27	0·25

DISCUSSION. *Metaldetes taylori* (R. & W. R. Bedford) differs from *M. irregularis* (R. & W. R. Bedford) by its narrow central cavity, weak development of vesicular tissue and the abundance of exothecal lamellae. It is little different from *M. dissepimentalis* (Taylor), which has straighter septa, a well-defined, double-porous outer wall, but is without any exothecal lamellae.

Genus ***METAFUNGIA*** R. & W. R. Bedford, 1934

1934 *Metafungia* R. & W. R. Bedford : 5.
1964 *Metafungia* R. & W. R. Bedford; Debrenne : 219
1965 *Metafungia* R. & W. R. Bedford; Hill : 119.

TYPE SPECIES. *Metafungia reticulata* R. & W. R. Bedford, by monotypy.

Diagnosis. Cup with central cavity that becomes free of skeletal tissue late in its development. The walls are double-porous. The intervallum is crossed by straight taeniae, which have their pores arranged in lines curving upwards and outwards; numerous synapticulae join the taeniae. The vesicular tissue is present at the base and in contact with tersioid outgrowths.

Composition of the Genus. *Metafungia reticulata* R. & W. R. Bedford.

Metafungia reticulata R. & W. R. Bedford

(Pl. 18, figs. 1–3)

1934 *Metafungia reticulata* R. & W. R. Bedford : 5, figs. 23 a–e.
1965 *Metafungia reticulata* R. & W. R. Bedford; Hill : 119, pl. 10, fig. 2 and text-fig. 22, 12 a–d.

Holotype. B.M. (N.H.) S 4184. Other Material S 4183.

Description. Large conical cup, the apex is surrounded by exothecal tersioid outgrowths and the central cavity is filled with endothecal tissue. The intervallum is crossed by straight, radial taeniae, which are perforated by pores, aligned upwards and outwards, in oblique rows. The diameter of these pores increases from the inner to the outer wall, giving an irregular appearance. The numerous synapticulae connect at the skeletal junctions of the taeniae. The vesicular tissue is only developed in the exo- and endothecal regions. The intervallar mesh, with some development of skeletal tissue and vertical closing of the apertures, corresponds to an outer wall. A regular micro-porous thin wall covers this externally. The inner wall may also be interpreted as a double wall. The inner part of each taenia has pores no larger than 0·7 mm; these taeniae are joined by small plates, resembling widened synapticulae, to form a small tube. On the central cavity side, a thin sheath is developed, with two pores to each tube, and has a more or less regular, hexagonal appearance.

Dimensions

	S 4183 Base (mm.)	(mm.)	S 4184 Top (mm.)
Cup:			
Height	..	35	..
Diameter	12	..	21
Intervallum	2·5	..	5
Intervallum coefficient	0·3	..	0·4
Interseptum	0·8	..	1·01
Synapticulae: radial distance	..	..	0·61
vertical distance	..	..	0·61
Outer wall:			
Diameter of main pores	..	0·70	..
Partitions	..	0·27	..
Thickness	..	0·2	..
Micropores: diameter	..	0·07	..
partitions	..	0·06	..

DIMENSIONS—*continued*

	S 4183 Base (mm.)	(mm.)	S 4184 Top (mm.)
Inner wall:			
Diameter of tubes	..	0·7–0·7	..
Partitions	..	0·27	..
Length of tubes	..	0·70	..
Inner pores: diameter	..	0·20	..
partitions	..	0·13	..
Septa:			
Thickness	..	0·13	..
Diameter of inner pores	..	0·25	..
Diameter of outer pores	..	0·40	..
Synapticulae:			
Thickness	..	0·13	..

DISCUSSION. *Metafungia reticulata* has an intervallar structure similar to that of *Flindersicyathus graphicus* (R. & W. R. Bedford). However, its size is much greater and the connecting synapticulae do not occur at every skeletal junction, but the essential difference is in the structure of the walls.

Family **METACOSCINIDAE** R. & W. R. Bedford

DIAGNOSIS. Two-walled porous cups. Taeniae and sparse convex tabulae.

COMPOSITION OF THE FAMILY. *Metacoscinus* R. & W. R. Bedford 1934, *Pycnoidocoscinus* R. & W. R. Bedford 1936, *Paracoscinus* R. & W. R. Bedford 1936, *Claruscyathus* Vologdin 1932, *Gabrielsocyathus* Debrenne 1964.

Genus ***METACOSCINUS*** R. & W. R. Bedford

1934 *Metacoscinus* R. & W. R. Bedford : 6, pl. 5, fig. 27.
1965 *Metacoscinus* R. & W. R. Bedford; Hill : 133, pl. 12, fig. 1, text-fig. 5 a–d.

TYPE SPECIES. *Metacoscinus reteseptatus* R. & W. R. Bedford, by monotypy.

DESCRIPTION. Conical cups, slightly waved externally. Oblique and vertical rods form the skeletal tissue of taeniae crossing the intervallum. These rods have considerable openings between them, which are much taller than wide and are roughly polygonal in shape. The outer pores are the largest. Less frequent horizontal structures regarded as tabulae, are perforated by small circular pores, that are separated by " linteaux " of varying size, and bear little irregular tubercles on each side.

Outer wall has funnel-shaped pores, circular on the intervallum side, larger and more irregular on their open outer side. Thin inner wall with two rows of large polygonal pores per intersept, separated by a thin skeletal mesh. R. & W. R. Bedford figured a specimen (1936 : fig. 83), which had several tubercles on its central cavity side.

Composition of the Genus. *Metacoscinus reteseptatus* R. & W. R. Bedford 1934, ? *Metacoscinus insigne* R. & W. R. Bedford 1936.

Discussion. *Metacoscinus insigne* is retained in this genus with some misgiving, until the type material can be revised. It has no visible tabulae and a thick outer wall with labyrinthoid pores. Nothing is known about the structure of these pores, whether their distorted shape is due to the fusion of several tubercles, as seen in the tabulae of *M. reteseptatus*, or results from lateral connection between neighbouring pore-tubes.

I have had the opportunity to examine the type material of *Metacoscinus gabrielsensis* (Okulitch 1955), *M. deasensis* (Okulitch 1955) and *M. poolensis* (Kawase & Okulitch 1957) loaned by the Geological Survey of Canada and have already suggested (Debrenne 1964 : 248), that these species should be regarded as a separate genus, *Gabrielsocyathus* Debrenne 1964, with *G. gabrielsensis* (Okulitch) as type species. This differs from *Metacoscinus* in having simply-porous, regularly-spaced tabulae; branching, or waved porous taeniae; a double, porous, outer wall with exotheca; endothecal lamellae partially filling the central cavity and extremely abundant vesicular tissue.

The species *poolensis* (Kawase & Okulitch) is included in *Gabrielsocyathus* with some reservations. The septa appear to undulate and bifurcate and have fewer pores than the other two species; the plates thicken at the junction with the septa; no exotheca occurs and the vesicular tissue is less abundant. The poor preservation of the specimen prevents confirmation of the presence of fine, irregular pores in all the skeletal plates.

Zhuravleva (1960 : 311) remarks that *Paracoscinus* and *Metacoscinus* are very close to each other and goes on to suggest that they might represent one genus, but since she had no material, it was difficult to make a definite decision. I have not seen the type of *Paracoscinus*, but from the figures and descriptions of R. & W. R. Bedford (1936 : 18, pl. 20, figs. 85–86), I consider that it differs from *Metacoscinus* in its wall structure (microporous and not a large open mesh); the abundant and regular plates, which have polygonal pores and are without tubercles; the thin outer wall and the inner wall with a single row of pores per interseptum.

Metacoscinus reteseptatus R. & W. R. Bedford

(Pl. 17, figs. 1–4)

1910 *Archaeocyathus retesepta* Taylor : 120, pl. 7, figs. 39–40.
1934 *Metacoscinus reteseptatus* R. & W. R. Bedford : 6, pl. 5, fig. 27.
1936 *Metacoscinus reteseptatum* R. & W. R. Bedford; R. & W. R. Bedford; 18, pl. 19, fig. 83.
1965 *Metacoscinus reteseptatus* R. & W. R. Bedford; Hill : 132–3, pl. 12, fig. 1, text-fig. 24, 5 a–d.

Material. Syntypes B.M. (N.H.) S 4191–4195. Other material S 4762, S 4772, S 4743, S 7633.

Description. Conical cups with transverse annular bulges. Outer wall has two vertical rows of funnel-shaped pores per intersept, the larger aperture on the outside,

with an irregular rim. Inner wall, also, has two vertical rows of pores, but these are polygonal and separated by very thin skeletal rods, without tubercles. Regular, radial pseudosepta, perforated by numerous hexagonal pores that are elongated upwards, or upwards and outwards in the annular bulges. Little vesicular tissue except in the lower part, where the pseudosepta are not so well developed and skeletal elements fill both the central cavity and the intervallum. Sparse tabulae, which have tubercles occurring between their two rows of quincunxial pores per intersept. The regular pattern of the pores is disturbed by the coalescence of neighbouring pores, or by anastomosed tubercles, giving these horizontal plates a vermiculate aspect, when seen from above.

Dimensions

	S 4191 (mm.)	S 4192 & S 4193 low (mm.)	S 4193 upper (mm.)	S 4195 (mm.)	S 4762 (mm.)
Cup:					
Height (pars)	21	base	..	25	20
Diameter	12	7	10	25–30	15
Intervallum	2	..	2	6	2·45
Central cavity	8	full	4	11	unknown
Interseptum	0·35	0·22	0·26	0·75	0·22
Intertabulum	1·7–3·4	..	..	..	..
Outer wall:					
No. of pore rows per interseptum	2–3	..	2	2	2
Diameter	0·15	..	..	0·18	0·15
Vertical partitions	0·06–0·10	..	..	0·15	0·06–0·10
Horizontal partitions	0·06–0·10	..	..	0·15	0·10
Thickness	0·30	0·26	..	0·18	unknown
Inner wall:					
No. of pore rows interseptum	2	..	2	2–3	1–2
Diameter	0·07	..	0·07	0·18–0·37	0·22–0·30
Vertical partitions	0·07	..	0·07	0·07	0·07
Horizontal partitions	0·07	..	..	0·07	0·15
Thickness	0·20	..	0·11	0·11	unknown
Septa:					
No. of pore rows	..	..	6	..	unknown
Diameter	0·15–0·37	..	0·22–0·40	0·56–1·51 0·26–0·52	0·26
Vertical partitions	0·07	..	0·07	0·18	0·13
Horizontal partitions	0·11	..	..	0·18	..
Thickness	..	..	0·07	0·11	0·07
Tabulae					
No. of pore rows	2	..	..	..	..
Diameter	0·11	..	..	..	..
Vertical partitions	0·11	..	..	..	..
Horizontal partitions	0·11	..	..	..	..
Thickness	0·15	..	..	..	..

DIMENSIONS—*continued*

	S 4772 (mm.)	S 4743 (mm.)	S 4743 lower (mm.)	S 4194 lower (mm.)	S 4194 upper (mm.)	S 7633 (mm.)	*retesepta* Taylor (mm.)
Cup:							
Height (pars)	unknown	12	..	30	..	..	90
Diameter	16	10	7	9	16	15	25
Intervallum	3·5	2	1·35	1·45	4·8	4	..
Central cavity	..	..	4·3 clear	skel. el.	..	..	..
Interseptum	0·5	0·22	0·33	0·41	0·37	0·34	0·45
Intertabulum	..	..	..	..	..	..	..
Outer wall:							
No. of pore rows per interseptum	2	2–3	unseen	2	2	..	2
Diameter	..	0·13	..	0·26–0·15	0·26–0·26	..	0·20
Vertical partitions	..	0·07	..	0·05	0·26–0·18	..	0·11
Horizontal partitions	..	..	..	..	0·11	..	..
Thickness	..	0·11	..	..	0·18	0·11	..
Inner wall:							
No. of pore rows interseptum	2	unseen	2	unseen	unseen	2–3	2–3
Diameter	..	..	unseen	..	0·18	0·15	0·15
Vertical partitions	..	..	..	..	0·07	0·11	0·10
Horizontal partitions	..	..	..	..	..	..	..
Thickness	..	..	0·07	..	0·11	0·11	0·10
Septa:							
No. of pore rows	7	..	7	5	7	..	..
Diameter	0·45	0·13–0·22	0·13	0·49	0·34–1·7	0·26	0·35
Vertical partitions	0·11	0·07	0·07	0·07	0·15	0·11	0·15
Horizontal partitions	..	..	..	0·15	0·15	..	..
Thickness	0·15	0·11	0·07	0·11	0·11	0·11	0·15
Tabulae:							
No. of pore rows	..	..	..	..	..	..	..
Diameter	..	..	..	..	0·11	..	..
Vertical partitions	..	..	..	..	0·10	..	..
Horizontal partitions	..	..	..	..	not visible	..	..
Thickness	..	..	..	..	0·15	..	..

DISCUSSION. R. & W. R. Bedford (1934 : 6) compared this species with *Archaeocyathus retesepta* Taylor, noting the likeness between the taeniae, but no horizontal structures were known in *A. retesepta*. Nevertheless, from Taylor's figures (Pl. 7, figs. 39 and 40), one can perhaps consider that the structures normal to those in the general direction are the beginnings of tabulae. Amongst all the specimens in the Bedford collection at the British Museum (Nat. Hist.), only S 4195 and S 4194 show these rare horizontal structures. The dimensions of the two species are of the same order and they are probably synonymous. Before joining them as a single species we need more material, in order to know the frequency and significance of these horizontal structures and to decide whether they have any systematic value, or are true tabulae, or are accidental features.

? Family **METACOSCINIDAE** R. & W. R. Bedford, 1936

Genus ***PYCNOIDOCOSCINUS*** R. & W. R. Bedford, 1936

1936 *Pycnoidocoscinus* R. & W. R. Bedford : 19, pl. 20, fig. 87.

Type Species. *Pycnoidocoscinus pycnoideum* R. & W. R. Bedford, by original designation.

Diagnosis. Cups with annular bulges on the outer wall, with the inner wall remaining cylindrical. Radial septa and arched tabulae. The outer wall is a porous mesh; the inner wall with both horizontal and vertical rows of rectangular pores.

Discussion. As the early stages are not known, it is difficult to classify this genus in either the Irregularia—indicated by the irregular outer wall and septa with numerous pores, or amongst the Regularia—as suggested from the type of inner wall with its rectangular apertures, the tabulae with the axis of curvature inside the intervallum, or the pore pattern of *Retecoscinus*-type. Only having examined a single broken fragment, it is not possible for me to offer any solution and the genus *Pycnoidocoscinus* is retained in the Metacoscinidae, but with some reservations.

Composition of the Genus. *Pycnoidocoscinus pycnoideum* R. & W. R. Bedford.

Pycnoidocoscinus pycnoideum R. & W. R. Bedford

(Pl. 18, figs. 4–8)

1936 *Pycnoidocoscinus pycnoideum* R. & W. R. Bedford : 19, pl. 20, fig. 87.

Material. B.M. (N.H.) S 4832. A syntype P 990 is in the South Australian Museum, Adelaide.

Description. Only one weathered and poorly preserved specimen has been examined. The intervallum is crossed by radial septa and arched tabulae. The septa are thickened near the inner wall and sometimes near the outer wall, but are very thin in the middle. Septal pores are not visible. Pores on a small, tangential surface of a tabula resemble those of *Retecoscinus* Zhuravleva (1960), with two alternating rows of oval to rectangular pores.

Outer wall eroded away; R. & W. R. Bedford have described it as " a layer of fine pores supported by an irregular mesh ". Inner wall has two rows of pores per interseptum and two rows of pores per intertabulum.

The vertical partition between the two interseptal pores, is the beginning of a new septum, which only develops in the inner third of the intervallum. Sometimes opposite this crude septa, another arises from the outer wall to meet it.

Dimensions

	(mm.)
Cup:	
Height (*pars*)	30
Diameter	22
Interseptum (at the inner wall side)	0·33
Intertabulum	1·22

DIMENSIONS—*continued*

	(mm.)
Outer wall:	weathered away
Inner wall:	
Diameter of pores	0·33
Vertical partitions	0·1
Horizontal partitions	0·06
Septa	
Diameter of pores	0·06
Vertical partitions	0·2
Thickness: middle	0·06
near inner wall	0·2
Tabulae:	
No. of pores per loculus	2 × 22
Diameter of pores	0·27–0·1
Partitions	0·1–0·13
Thickness	0·1

DISCUSSION. The rows of rectangular pores of the inner wall and the presence of " rods " in the middle of the interseptum (interpreted here as the beginnings of new septa) are good reasons for including S 4832 in *P. pycnoideum*. Unfortunately, poor preservation and the lack of an apex prevents any clarification of the systematic position of *Pycnoidococsinus*.

III. STRATIGRAPHICAL CONCLUSIONS

The excellent silicified fossils found in the Australian Cambrian, as well as being extremely useful for anatomical studies of the Archaeocyatha, are also of considerable stratigraphical interest.

We have little information on the precise horizon in the Ajax Limestone, from which the Bedfords collected their fossils. According to Daily (1956 : 129), " . . . Most, if not all, of the species described from the Ajax Mine area by Taylor and the Bedfords, are believed to have come from beds containing this assemblage [i.e. faunal assemblage No. 1], for it is significant that no fossils characteristic of faunal assemblage No. 2 have been reported by them. Such fossils would almost certainly have been noticed if they were present . . . ". However, Walter (1967) comments (p. 145) that the rich Ajax fauna described by the Bedfords & Taylor, cannot be placed in Daily's scheme of faunal units. This is because, in an area of complex structure, it was not collected in sequence and the additional evidence of the fauna associated with the archaeocyathids is not available. As a result it is of very limited stratigraphical use.

The out-dated studies of Taylor and the too brief publications of the Bedfords, have not allowed specialists in other countries to make precise comparisons and possible correlations, between their material and that of Australia. An attempt was made on the limited material available in the Ting collection (F. & M. Debrenne 1960). It was concluded, from the majority of genera appearing at Beltana, that the fauna belonged to the Aldanian and Lower Lenian stages. Since then, I have become acquainted with Russian work that amends the stratigraphical correlation between the Southern Siberia geosyncline and the Siberian platform, and gives detailed lists of revised Archaeocyatha faunas from level to level.

These data, together with the present study, confirm that the Ajax Limestone is situated in the lower half of the Lower Cambrian; to be precise, the fauna is similar to that of the Kameshki horizon and also has a certain affinity with those forms found in the succeeding Sanashtygkol horizon. This opinion is based on the presence, in the Ajax fauna, of forms having advanced evolutionary stages of outer and inner walls, or intervallar structures, together with other simple forms known from the Bazaikha horizon, such as *Monocyathus*, *Alphacyathus*, *Ajacicyathus*, *Robustocyathus* and *Erismacoscinus*.

As examples of the advanced forms, one can show the presence of genera with:

1. Outer walls with simple tumuli (*Tumuliolynthus*, *Ethmocoscinus*), or multiperforate (*Alataucyathus*).

   According to Rozanov (1963 : 8) genera with tumuli mainly arise in the Kameshki horizon.
2. Double porous outer wall (*Tomocyathus*, *Polycoscinus*).

   This feature appears at the end of the Bazaikha horizon and genera that possess it increase in numbers through the Kameshki and Sanashtygkol horizons.
3. Inner wall with complex annular rings.

   This is seen in *Cyathocricus annulispinosus* (Vologdin) found in the Kameshki horizon of Eastern Sajan, and the Australian species *annulatus* (Bedford) regarded as belonging to *Salairocyathus*, which occurs in the Sanashtygkol horizon.
4. Inner wall with branching pore-tubes (*Zonacyathus*).

   Three Russian species probably belong to this genus; *poletaevae*, *vermiculatum* and *flexum*. They and the corresponding colonial genus *Sajanocyathus* are of Sanashtygkol age.
5. Radial septa with few, or no pores (*Cyathocricus*, *Ethmocyathus*, *Zonacyathus*, *Robustocyathus subacutus* and *Archaeocyathellus* (*Stapicyathus*) *stapipora*).

   Zhuravleva (1960 : 147) and Rozanov & Missarzhevsky (1966 : 71) consider that the decrease or loss of septal porosity is an evolutionary character of the Regularia. The pores of the plates are often different to the septal pores in Australian *Coscinocyathus*, whereas in specimens found at lower levels in the Cambrian (e.g. Soussian horizon in Morrocco) they are very similar. The first appearance of any difference between the two occurs in the Sardinian limestones, contemporaneous with the Botoma Stage of Southern Siberia.

LOWER CAMBRIAN

These correlations are taken from Table II of Walter (1967), who used information given in a personal communication (Sept. 1966) to M. F. Glaessner by A. Yu. Rozanov.

SIBERIAN PLATFORM		GEOSYNCLINE OF SOUTHERN SIBERIA	
	Lower subdivision		
TOMMOT STAGE	Sunnagin	ALDAN STAGE	Kundatsk horizon
	Kenyada		Bazaikha horizon
	Atdaban		Kameshki horizon
	Tarynsk		
	Sinsko-Kutorgina	BOTOMA STAGE	Sanashtygkol horizon

Upper subdivision		
Ketema	LENA STAGE	Solontsov horizon
Elanka		Obruchev horizon

Similar studies of evolutionary stages, have not been made for the Irregularia, but it is possible to make the following points.

1. The first Irregularia have scattered skeletal elements, rods, or plates, as in *Dictyocyathus*, or *Protopharetra* and are of Soussian age. They then follow two particular paths.
   a. The plates of *Protopharetra* gave rise to the crude pseudo-septa of *Volvacyathus*-type, where the pores occupy a greater surface area than the skeletal tissue; then into the poorly developed pseudosepta shown in the first *Metaldetes* of Sardinia; followed by the definite radial septa of the true *Metaldetes* of Australia and ending with the *Cambrocyathus*-type, which occurs in the upper half of the Lower Cambrian.
   b. The rods of *Dictyocyathus*, on the other hand, form the regular scaffolding of *Flindersicyathus* and *Pycnoidocyathus* types, which are comparable to the intervallar structure of Tabellaecyathidae Fonin, characteristic of the Sanashtygkol horizon.
2. Amongst the Ajax fossils one finds *Syringocnema*, a genus characterized by prismatic loculi in the intervallum. In the USSR the species referred to this genus are limited to the Sanashtygkol horizon.
3. The walls of the Irregularia are not so diverse as those of the Regularia. In the older forms of *Dictyocyathus* and *Protopharetra* they are not independent of the intervaller structural elements. This is attained in the genus *Flindersicyathus*, with its simply porous outer wall and inner wall having pore-tubes, the lower parts of which are modified and stretched. The double porous inner wall is seen in the genera *Metaldetes*, *Metafungia* and *Metacoscinus*. Such structures indicate the development of more advanced features, e.g. lamellae and tabulae, that are known in the Sanashtygkol horizon (Fonin 1963).

All these considerations show that there are clear affinities between the Ajax faunas and those of the Kameshki and Sanashtygkol horizons. The absence of forms with clathrate outer walls, or inner walls of true *Ethmophyllum*-type, shows that the Sanashtygkol fauna was not well established in Australia at the time of the Ajax limestone. The fauna is, therefore, probably of Upper Kameshki and Lower Sanashtygkol age, that is to say the middle part of the lower division of the Lower Cambrian.

Since this conclusion was first written Walter (1967), in his study on the usefulness of Archaeocyatha for zoning and correlation in the Lower Cambrian of the Adelaide Geosyncline, has correlated the various faunas in the Hawker Group of South Australia with those of Siberia. Using genera as the basis of such correlation, he has assigned a Sanashtygkol age to the Oraparinna Shale; the latter occurs above the

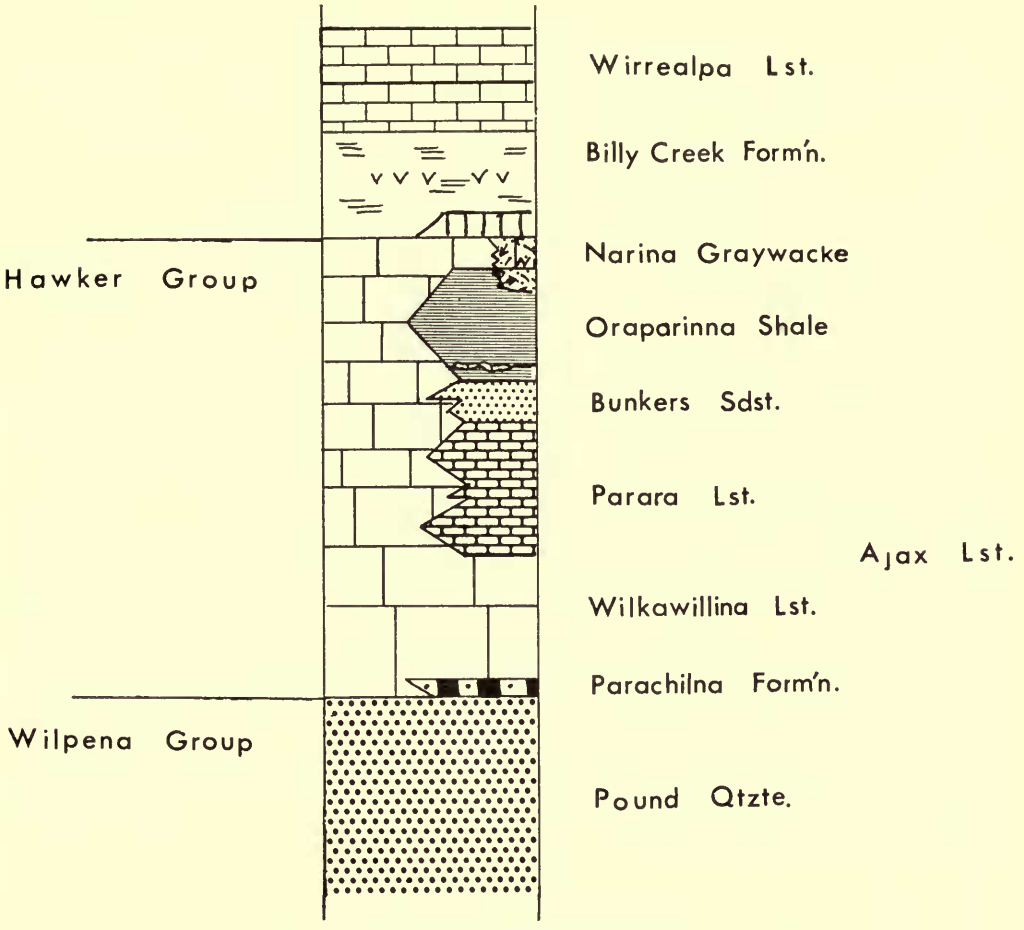

FIG. 15. Lower Cambrian Sediments, Flinders Ranges; S. Australia. After Dalgarno (1964) & Walter (1967).

Wilkawillina Limestone of which, in the Mt. Scott Range area, the Ajax Limestone is said to be the equivalent (Dalgarno 1964 : 136). Commenting on the Ajax Limestone Walter (p. 146) suggests that the presence of *Syringocnema*, *Flindersicyathus* and *Pycnoidocyathus* indicate correlation with the upper part of the Hawker Group in the Wilkawillina Gorge section and concludes that, in the Ajax Mine area, the Ajax Limestone may be another bioherm. This evidence would appear to support my conclusions as to the age of the fauna of the Ajax Limestone.

IV. SUMMARY

The material now in the British Museum (Natural History), collected and originally described by R. & W. R. Bedford, has been revised according to current classification.

It is considered necessary to create a separate family within the Ajacicyathacea for the genus *Ethmocyathus*, which is characterized by a secondary wall of annular plates on the central cavity side of the inner wall. A new genus, *Cyathocricus*, is introduced for *Bronchocyathus* Bedford, which did not conform to the rules of zoological nomenclature, and includes those forms belonging to the Bronchocyathidae that have a more complex inner wall than *Cyclocyathus*. Two species are assigned to the new genus.

A new subgenus *Loculicyathus* (*Loculicyathellus*) is distinguished from *Loculicyathus* (*Loculicyathus*) by the longitudinal corrugations occurring between the septa on the outer wall. Two new subgenera are introduced for the smooth inner wall forms of *Tomocyathus: T.* (*Erugatocyathus*) and *Alataucyathus* : *A.* (*Anaptyctocyathus*). A new species of the latter is erected, *A.* (*A.*) *flabellus*, which is distinguished from *A.* (*A.*) *cribripora* by its bowl-shaped cup, dimensions and arrangement of wall pores.

In the broader classification, the family Acanthinocyathidae is distinguished from the Dokidocyathidae, and the family Bronchocyathidae is re-introduced to take the new genus *Cyathocricus*. The genus *Flindersicyathus* is included in the re-introduced family Flindersicyathidae, as there are many characters of this genus which distinguish it from *Archaeocyathus*. *Pycnoidocyathus* and *Flindersicyathus* are treated as subgenera until the Ajax Mine material in both Princeton and Adelaide is re-studied.

Owing to both the poor preservation and limited number of some specimens, it has been impossible to see sufficient structural details for exact determination and the true position of several genera remains uncertain. However, the good condition of other material has enabled a thorough study of the internal skeleton to be made, with the result that new types of structure have been discovered, e.g. the annular form of the inner wall in *Salairocyathus* (*S.*) *annulatus*.

From the stratigraphical evidence, it is concluded that the fauna is of middle Lower Cambrian age, i.e. upper Kameshki—lower Sanashtygkol horizons, and this has been borne out by subsequent work.

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APPENDIX

GLOSSARY

APEX	initial part of cup.
CENTRAL CAVITY	space inside the inner wall.
DISSEPIMENTS	non-skeletal vesicular connections between the septa.
ENDOTHECA	tissue formed on the central cavity side of the inner wall.
EXOTHECA	diverse external outgrowths from the intervallum and outer wall.
INTERSEPT/INTERSEPTUM	space between two adjacent septa.
INTERTABULUM	space between 2 successive tabulae.
INTERVALLUM	space between the inner and outer walls.
LINTEAUX	skeletal elements around the pores.
LOCULUS	space limited by the two walls, two adjacent septa and on occasion by two successive tabulae.
PELLIS	thin calcareous sheath, porous or not, outside the walls of some genera.
PORES	simple perforations in the skeletal elements.
SEPTA	porous, radial vertical plates connecting the inner and outer walls.
SYNAPTICULAE	horizontal rods between 2 neighbouring septa.
TABULAE	straight, or curved; porous, or pectinate plates that cross the intervallum.
TAENIAE	thick, skeletal; irregular, or waved; sometimes gondola-shaped, plates, that radially subdivide the intervallum and are only found in the Irregularia.
TUMULI	wall protuberances.